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The Mackenzie Basin

Proceedings of the Intergovernmental Seminar Held at Inuvik, N.W.T., June 24-27, 1972.

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Preface

The Mackenzie River Basin has an area of over 700,000 square miles and occupies parts of Canada's three westernmost provinces and the northern territories. Within its boundaries are the major sub-basins of the Peace, Athabasca, and Liard Rivers as well as four major lakes: Great Bear, Great Slave, Lesser Slave, and Athabasca. The Mackenzie River system played a historic role in the exploration and development of Canada and now is emerging as a major economic resource for the future. Its rivers are of primary importance in the transport of equipment and materials for oil and gas explorations in the North.

The current northward thrust of modern technology and the increasing interest in water power, water supply and recreational development clearly shows the growing national and regional importance of the Mackenzie River. These factors, coupled with the increasing awareness of existing and emerging jurisdictional conflicts, attest to the need for cooperative approach by the various governments represented within the Basin.

In June of 1972, officials of the Federal, British Columbia, Alberta, Saskatchewan, Yukon and Northwest Territorial Governments held the first intergovernmental seminar on the Mackenzie River at Inuvik, N.W.T. Prompted by the Northwest Territories Council's concern over future Basin developments, some 40 delegates representing departments and agencies from the various governments met to focus attention on the Mackenzie and to confront those problems both directly and indirectly related to water resources. More specifically the objectives of the seminar were:

(1) to exchange information,
(2) to assess the need for joint intergovernmental action, and
(3) to consider appropriate courses of action.

The seminar was structured in three parts. In the opening session, background papers were presented by Environment Canada, the Province of Alberta, the Canada Ministry of Transport, the Province of British Columbia, the Northern Region Group (Canada Department of Indian and Northern Affairs and the Northwest and Yukon Territorial Governments) and the Province of Saskatchewan. For the second session, delegates separated into four working groups, each group having a cross-section of delegates from the various jurisdictions represented at the Seminar. Here the delegates explored in detail the questions raised in the background papers in order to define areas of mutual concern and to identify alternative courses of co-operative action which might be taken. Lead delegates, representing the respective governments, then met in a third session to consolidate the views and conclusions of the four working groups into a summary report for the Seminar. This was presented to a plenary session on the last day.

These Proceedings provide a concise record of the Seminar. It is hoped that the background papers, the summary of discussions and conclusions contained herein will provide a starting point for developing more effective communication and co-operation in the management of the Mackenzie River Basin.

Thanks is extended to all individuals who contributed to the Seminar and for the northern hospitality extended by the Northwest Territorial government. Special mention must go to the program and arrangement committees headed by Mr. F.J. Forbes. Members of the program committee were Mr. R.E. Bailey, Alberta; Mr. S.R. Blackwell, Saskatchewan; Mr. L. Brandon, Yukon; Mr. F.J. Forbes, Environment Canada; Mr. D.J. Gee, Northwest Territories; and Mr. A.H. Jones, Indian and Northern Affairs, Canada. The arrangements committee chaired by Mr. A.H. Jones consisted of Mr. D.J. Gee and Mr. J.A. Bergasse, Northwest Territories; and Mr. J.G.M. Parkes, Environment Canada.

Special thanks is also due the following individuals who prepared and presented background papers: Mr. W.G. Anderson, Ministry of Transport, Canada; Mr. R.E. Bailey for Alberta; Mr. S.R. Blackwell for Saskatchewan; Mr. B.E. Marr for British Columbia; Mr. J.G.M. Parkes, Environment Canada; and Mr. A.B. Yates, on behalf of Northern Region Group. Finally, the efforts of Messrs. A.G. Thomas and D.N. Scharf must be noted for their effort in compiling the Proceedings.

Jean Lupien,
Senior Assistant Deputy Minister,
Environmental Services.

Press Release

After completion of seminar on Mackenzie Basin the following was given to the Press.

Officials of the Federal Northwest Territories and Provincial Governments of British Columbia, Alberta and Saskatchewan met at Inuvik to exchange information and data on the Mackenzie River Basin. The seminar, which resulted from an expression of concern by the territorial council provided the 40 delegates with an excellent means of focussing attention on the Mackenzie Basin.

The Mackenzie River Basin, one of the largest on the continent, has a drainage area of approximately 700,000 square miles. Included in the system are the major sub-basins of the Peace, Athabasca, Liard and Great Bear Rivers as well as four major lakes: Great Bear, Great Slave, Lesser Slave and Athabasca.

While many of the possible developments mentioned at the seminar were conceptual in nature, nevertheless the interdependence of the various regions within the basin suggests the need for exchange of information and data among the several jurisdictions. Such an exchange would better permit each jurisdiction to identify its needs and priorities for additional studies within its region. Also the seminar recognized the need for collection of additional data including water quality and quantity as a first priority. To this should be added information on fisheries, wildlife, forestry, transportation and economic development which could affect or be dependent upon the water resources.

The seminar arrived at a consensus that more basic data and information are needed and that future action will depend on decisions by the leaders of government of the several jurisdictions. Because policies, budgets and priorities will be factors, several possible procedures were listed for their consideration.

Background papers presented at the seminar will be prepared for public release.

French Press Release

Quelque 40 représentants de toutes les juridictions du fleuve Mackenzie se sont réunis du 24 au 27 juin à Inuvik. Ce bassin de 700,000 milles carrés, un des plus riches au monde, fut le sujet d'un examen des différentes autorités.

L'interdépendence de tous les projets possibles dans le bassin du Mackenzie a convaincu les diverses autorités de la nécessité de travailler ensemble.

Plusieurs techniques de travail furent examinées pour référence aux gouvernements concernés.

Program, Participants and Working Groups

Program

Saturday, June 24

8:00 p.m. – Registration
– Informal Reception hosted by Indian and Northern Affairs

Sunday, June 25

10:00 – 12:00 a.m. – Barge tour of Delta area

SESSION I – PRESENTATION OF BACKGROUND PAPERS

3:00 – 3:30 p.m. – Opening Remarks
3:45 – 5:30 p.m. – Papers by: Environment Canada
Alberta
Arctic Transportation Agency
7:00 p.m. – Banquet hosted by Government of Northwest Territories

Monday, June 26

9:15 – 10:15 a.m. – Papers by: British Columbia
Northern Region Group
Saskatchewan

SESSION II – DISCUSSIONS ON NEED FOR INTER-GOVERNMENTAL ACTION

10:30 – 11:00 a.m. – Structuring of Working Groups
11:00 – 12:00 a.m. – Discussions by Working Groups
1:00 – 3:00 p.m. – Discussions by Working Groups
3:00 – 4:30 p.m. – Reports by Working Groups

Tuesday, June 27

SESSION III – DRAFTING CONCLUSIONS AND RECOMMENDATIONS ON GOVERNMENTAL ACTION

9:00 – 11:00 a.m. – Lead Delegates consider Working Group Reports
11:30 – 12:00 a.m. – Report of Lead Delegate to Plenary Session
– Prepare Press Release
12:30 – 1:30 p.m. – Luncheon hosted by Environment Canada

Participants

Northern Regional Group

INDIAN AFFAIRS AND NORTHERN DEVELOPMENT – OTTAWA

Mr. A. D. Hunt	Assistant Deputy Minister, (Northern Development)
Mr. A. B. Yates	Director; Northern Economic Development Branch, Northern Development Program
Mr. J. K. Naysmith	Chief; Water, Forests and Lands Division, Northern Development Program
Mr. F. A. McCall	Assistant Chief, Water, Forests and Lands Division, Northern Development Program
Mr. A. H. Jones	Acting Head; Water Section, Water, Forests and Lands Division, Northern Economic Development Branch

INDIAN AFFAIRS AND NORTHERN DEVELOPMENT – TERRITORIAL

Mr. G. B. Armstrong	Regional Director of Resources, Yellowknife, N. W. T.
Mr. D. J. Gee	Regional Manager; Water, Forests and Land, Yellowknife, N.W.T.
Mr. A. Redshaw	Controller of Water Rights, Yellowknife, N.W.T.
Mr. L. V. Brandon	Regional Manager; Water, Forests and Land, Whitehorse, Yukon
Dr. A. B. Hollingshead	Controller of Water Rights, Whitehorse, Yukon

TERRITORIAL GOVERNMENT

Mr. J. A. Bergasse	Acting Director; Department of Industry and Development, Government of the Northwest Territories, Yellowknife, N.W.T.
Mr. J. C. Birt	Industrial Development Officer, Department of Industry and Development, Government of the Northwest Territories, Yellowknife, N.W.T.

Environment Canada

Mr. Jean Lupien	Senior Assistant Deputy Minister, Hull, P.Q.
Mr. L. Edgeworth	Assistant Deputy Minister, (Water Management), Ottawa, Ontario.
Mr. A. T. Davidson	Assistant Deputy Minister, (Policy Planning & Research), Hull, P.Q.
Dr. A. T. Prince	Director General, Inland Waters Directorate, Ottawa, Ontario.
Mr. N. H. James	Director; Water Planning and Management Branch, Inland Waters Directorate, Ottawa, Ontario.
Mr. S. Reeder	Head; Western Region, Water Quality Branch, Calgary, Alberta.
Dr. W. N. English	Deputy Director; Pacific Region, Marine Sciences Directorate, Victoria, British Columbia.

Dr. A. H. Macpherson — Chairman; Prairie and Northern Region Board *and* Director, Western Region, Canadian Wildlife Service.

Mr. B. J. Eagen — Chief Administrator, Inland Waters Directorate, Ottawa, Ontario.

Mr. J. G. M. Parkes — Resource Planning Officer, Inland Waters Directorate, Ottawa, Ontario.

Ministry of Transport

Mr. W. G. Anderson — Director of Planning, Arctic Transportation Agency, Ottawa, Ontario.

Saskatchewan

Hon. N. Byers — Minister of the Environment, Regina.

Mr. G. E. Couldwell — Director; Fisheries and Wildlife, Department of Natural Resources, Regina.

Mr. S. R. Blackwell — Director; Investigation and Planning Branch, Department of the Environment, Regina.

Mr. B. Hill — Department of Northern Saskatchewan, Regina.

Mr. W. Howard — Department of Environment, Regina.

British Columbia

Mr. B. E. Marr — Chief Engineer; British Columbia Water Resource Service, Victoria.

Mr. Howard deBeck — Comptroller of Water Rights, British Columbia Water Resources Service, Victoria.

Mr. W. N. Venables — Director of Pollution Control, British Columbia Water Resource Service, Victoria.

Alberta

Hon. A. A. Warrack — Minister, Department of Lands and Forests, Edmonton.

Dr. E. E. Ballantyne — Deputy Minister, Department of the Environment, Edmonton.

Dr. V. A. Wood — Deputy Minister, Department of Lands and Forests, Edmonton.

Mr. R. E. Bailey — Director; Water Resources Division, Department of the Environment, Edmonton.

Dr. S. Smith — Alberta Environment Conservation Authority, Edmonton.

Observers

Mr. G. Mullins — Federal Treasury Board, Government of Canada.

Mr. T. H. Butters — Member, Western Arctic, Council of the Northwest Territories, Inuvik, N.W.T.

Mr. L.R. Trimble — Member, Lower Mackenzie, Council of the Northwest Territories, Inuvik, N.W.T.

Working Groups

No. 1	No. 2	No. 3	No. 4
Blackwell, S.R. (Leader)	Marr, B.E. (Leader)	Bailey, R.E. (Leader)	Jones, A.H.
Howard, W. (Rapporteur)	Bergasse, J.A. (Rapporteur)	Mullins, G. (Rapporteur)	Parkes, J.G.M.
Birt, J.C.	Anderson, W.G.	Butters, T.H.	Armstrong, G.B.
Brandon, L.V.	Ballantyne, E.E.	English, W.N.	Couldwell, G.E.
deBeck, H.	Byers, N.E.	Hill, B.	Davidson, A.T.
Edgeworth, L.	Hung, A.D.	Hollingshead, A.B.	Redshaw, A.G.
Gee, D.J.	James, N.H.	Lupien, Jean	Trimble, L.R.
MacPherson, A.H.	McCall, F.A.	Naysmith, J.K.	Venables, W.N.
Warrack, A.A.	Reeder, S.	Smith, S.	Wood, V.A.
	Yates, A.B.		

Background Papers

Session I

Presentation of Background Papers

Mr. Edgeworth opened the Seminar and expressed his appreciation for the co-operation of the respective governments and the interest shown by participating delegates. In briefly reviewing the Seminar objectives he noted the growing importance of the Mackenzie River System and the rapidly increasing demands which are being made on the resources of the Basin. He then outlined the Seminar program noting that the purpose of the first session is to have the various governments describe their interests and concerns for the future development of the water resources of the Basin.

The Environment Canada paper, presented by Mr. J.G.M. Parkes, described the geology, geography, hydrology, natural resources and socio-economic aspects of the Basin. The Alberta presentation, read by Mr. R.E. Bailey, Alberta Department of Environment, discussed possible water resource developments in the Alberta portion of the Basin. Mr. W.G. Anderson, of the Arctic Transportation Agency, Canada Ministry of Transport, then presented a paper dealing with navigational problems in the Mackenzie River System.

The following day, Mr. B.E. Marr, of the British Columbia Water Resources Service, continued the session with a paper discussing diversion possibilities in the British Columbia section of the Basin. Mr. A.B. Yates of the Department of Indian and Northern Affairs (INA), then spoke on behalf of the Northern Region Group (I.N.A. and the Northwest and Yukon Territorial Governments). This paper deals with I.N.A.'s responsibility for natural resource planning, development and management north of 60° and with the Government of the Northwest Territories' concern about possible effects of upstream diversion and storage schemes on the lower reaches of the Mackenzie. The concluding paper read by Mr. S.R. Blackwell, Saskatchewan Department of the Environment, discussed the Saskatchewan portion of the Basin including the possibilities for tourism, hydro power and diversions.

Environment Canada

The Mackenzie Basin

WATER MANAGEMENT SERVICE,
ENVIRONMENT CANADA.

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Illustrations

Illustrations (cont.)

The Mackenzie River Basin

1. DESCRIPTION OF THE BASIN

Spanning three time zones and draining one-fifth of the total area of Canada, the Mackenzie ranks as one of the world's largest river systems. Its scale is enormous, as shown by its 700,000 square mile drainage area — equivalent to the land areas of Great Britain, France, Germany, Spain, Portugal and Italy combined.

The basin occupies the central portion of western Canada and straddles a north-south axis extending from Maligne Lake in Alberta to the Arctic Ocean (Fig. 1). It occupies portions of three provinces and the two territories: 125,000 square miles of northeastern British Columbia, 178,000 square miles of northern Alberta, 57,000 square miles of northwestern Saskatchewan, and 54,000 square miles of the northeastern and southeastern portions of the Yukon Territory. The remaining 282,700 square miles lie within the District of Mackenzie, Northwest Territories.

The Mackenzie River system is both the largest in drainage area and the longest in Canada, flowing approximately 2,635 miles from the headwaters of the Finlay River to the Arctic Ocean. It is surpassed only by the St. Lawrence River in discharge volume. Its three major tributaries are the Peace, Athabasca and Liard Rivers with drainage areas of 125,200, 62,900 and 108,700 square miles respectively (Fig. 1). The Athabasca River rises in the Rocky Mountains of western Alberta and flows 765 miles in a northeasterly direction into Lake Athabasca. The Peace River rises in the mid-Rockies of northeastern British Columbia and flows generally eastward until it joins a short drainage channel from Lake Athabasca to form the Slave River. The Slave thence flows north for approximately 280 miles and empties into Great Slave Lake. The Liard River rises in the southeastern part of the Yukon, and follows a southeasterly course into British Columbia, but soon turns northeastward to meet the Mackenzie at Fort Simpson.

The name "Mackenzie River" is applied to that part of the system that extends from Great Slave Lake to the Arctic coast. Other sizable tributaries join the river downstream: the Arctic Red and the Peel Rivers from the mountains to the west and the Great Bear River from Great Bear Lake to the east.

Topographically, the Mackenzie Basin can be divided into three distinct physiographic regions, each of which runs parallel to the others along a north-south axis. The rugged mountain ranges along the west side of the basin are part of the eastern system of the North American Cordillera. The Rocky Mountain area in the south rises to more than 10,000 feet, while the Mackenzie Mountains to the north average 6,000 — 7,000 feet in elevation. These high ranges are broken by several low, narrow plateaus and plains associated with the main rivers.

Through the centre of the basin is the Interior Plain, a series of gently rolling plateaus and lowlands which constitute approximately one-third of the Basin area. This region is extensively covered by glacial drift and is characterized by countless lakes and large areas of muskeg and swamp. The Interior Plain is made up of the Alberta Plateau in the south (2,000-3,000 feet in elevation), and is separated by an escarpment from the Mackenzie Lowlands, which slope northward to the Arctic Ocean.

The basin also encompasses the western edge of the Canadian Shield. This region has been extensively glaciated and, as a result, is characterized by lakes, swamps and muskeg interspersed with small hummocks of glacial drift. Here may be found the three large lakes of the Mackenzie Basin: Great Bear Lake (12,096 square miles), Great Slave Lake (11,030 square miles), and Lake Athabasca (3,064 square miles).

The majority of the Mackenzie Basin has a subarctic climate characterized by short, cool summers and low mean annual precipitation, ranging from 18 inches in the south to 5 inches in the north.

Vegetation in the Basin is closely related to climate. Tundra vegetation is characterized by moss-lichen plant communities and an absence of trees. The warmer part of the subarctic region in the south is dominated by the white and black spruce of the Boreal Forest. Broadleaf species such as poplar and birch become increasingly common toward the south, and several "islands" of aspen parkland occur. Except for a continuation of the Boreal Forest in the southern half of the Mackenzie River valley, the northern portion of the Basin is in the transitional taiga zone between the tundra and the Boreal Forest. Depending upon

Figure 1
MACKENZIE BASIN
INTERGOVERNMENTAL SEMINAR

LOCATION

- Latitude – between 52°N and 69°N (approx.)
- Longitude – between 103°W and 140°W (approx.)
- North-South Axis – Beaufort Sea – Maligne Lake, Alberta – 1,350 miles
- East-West Axis – Fort Reliance, N. W. T. – Dease Lake, B. C. – 900 miles

THE BASIN AND SUB-BASINS

- Total Length of System – 2635 miles
- Total Basin Area – 696,700 square miles

Major Sub-Basins	Sub-Basin Area	River Length
• Peace River	117,200 square miles	750 miles
• Athabasca River	62,900 square miles	765 miles
• Lake Athabasca	51,800 square miles	–
• Great Slave Lake	131,300 square miles	–
• Liard River	108,700 square miles	680 miles
• Great Bear Lake & River	60,900 square miles	–

BASIN GEO-POLITICAL AREAS

Province/Territory	Area
• British Columbia	125,000 square miles
• Alberta	178,000 square miles
• Saskatchewan	57,000 square miles
• Yukon Territory	54,000 square miles
• Northwest Territories	282,700 square miles

MAJOR LAKES

Lake	Area
• Great Bear Lake	12,096 square miles
• Great Slave Lake	11,030 square miles
• Lake Athabasca	3,064 square miles

FACT SHEET NO. 1: KEY BASIN DATA

local climate, relief and soils, the northern portion of the basin combines the characteristics of both tundra and forest.

The dominant soils of the Interior Plain south of the permafrost line are the Grey Wooded and Grey Brown types associated with the Boreal Forest. To the north, both permafrost and the colder climate hinder soil development. Organic soils made up the large areas of muskeg throughout the Basin. In the shield area, Podzols are interspersed with organics and areas of bare rock. The Cordillera Region, because of its complex terrain, exhibits a number of soil types, predominantly undifferentiated mountain soils.

2. GEOLOGY

The geology of the Mackenzie River Basin, while very complex in structure, may be generally divided into three regions. They are: (1) the Western Cordillera, (2) the Interior Platform, and (3) the Canadian Shield (Fig. 2). These regions are very similar to the three physiographic regions although local topography may alter the boundaries somewhat. The Western Cordillera is largely formed of sedimentary rocks with hard metamorphosed igneous rocks mechanically squeezed into the various sedimentary strata; the Interior Platform is primarily beds of sedimentary rocks of varying ages, and the Canadian Shield is Pre-Cambrian igneous granites and gneisses with bands of volcanic and sedimentary rocks.

2.1 The Western Cordillera

The Cordillera is divided into the Eastern System, composed almost entirely of folded sedimentary strata, and the Interior System, comprised of a mixture of folded sedimentary and volcanic strata, massive metamorphic

rocks, all intruded by and interbedded with numerous bodies of igneous and volcanic rocks. (Fig. 2)

The Cordillera is basically an erosion surface, thought to have been formed in early Tertiary or possibly late Cretaceous time, that has gone through a complicated series of uplift, warping, subsidence and renewed uplift. In the early Tertiary, the old erosion surface was uplifted, rivers entrenched, and sediments deposited in valleys and hollows. Early Tertiary volcanics, chiefly lavas, subsequently filled the valleys. They were later folded, warped and subsequently eroded during renewed uplift. Lava was periodically extruded onto the ridges of the high mountains.

The Eastern System of the Western Cordillera consists of part of the Northern Yukon Fold Belt, the Mackenzie Fold Belt and the Rocky Mountain Thrust Belt.

The section of the Northern Yukon Fold Belt within the Basin includes portions of the Porcupine Plateau, Taiga Ranges, the Ogilvie Mountains and the Richardson Mountains.

The Richardson Mountains form a narrow north-south belt rising between the Porcupine Plateau on the west and the Arctic Coastal Plain and the Peel Plateau. In this area most of the strata dip easterly at an angle of 25 to 40 degrees, creating deep V-shaped valleys and steep ridges. Most of the rock is sedimentary, with late Mesozoic sandstones and shales overlying Devonian sandstones and quartzites.

The Mackenzie Fold Belt consists of the Liard Plateau, Franklin Mountains, Mackenzie Plain, Mackenzie Mountains and Peel Plateau.

The Liard Plateau is a broad plateau of even-topped ranges of hills created by intensive folding. The geology of the plain is a northward extension of that found in the Rocky Mountain Thrust Belt, namely Paleozoic and Mesozoic sediments.

The Franklin Mountains form the eastward boundary between the Cordillera and the Interior Platform. They are 350 miles long, approximately 30 miles wide and composed of four ranges: Nahanni, Camsell, McConnell and Norman Ranges. They consist of Devonian sediments (sandstone, siltstone, shale, limestone, dolomite), and late Cambrian sediments (dolomite, limestone, shale, sandstone, conglomerate).

The Mackenzie Plain is an area of low elevation and relief between the Franklin Mountains and the Mackenzie Mountains. Around Fort Wrigley it is composed of folded Cretaceous and Tertiary strata and towards the south, an anticline of Paleozoic rocks projects through the Cretaceous strata.

The Mackenzie Mountains are divided into the northeast Canyon Range, and the southwest Backbone Range. The latter contains intrusives and metamorphics along with Paleozoic carbonate rocks, while the Canyon Range consists basically of Devonian sediments (sandstones, shales, limestones).

The Peel Plateau is bordered by the Mackenzie Mountains on the south and the Richardson Mountains on the west. The Plateau truncates the upturned edge of the Paleozoic and Mesozoic strata. The centre of the Plateau is composed of a series of horizontal strata of Cretaceous age.

The Rocky Mountain Thrust Belt, which includes the Rocky Mountain Foothills, Rocky Mountains, and the Rocky Mountain Trench, is 60 to 100 miles wide, and extends for 900 miles from the forty-ninth parallel to the Liard Plateau.

The Foothills are sedimentary in origin, typically folded and faulted in narrow parallel belts and are composed of soft Cretaceous or early Tertiary beds of sandstones, shales and conglomerates as well as volcanic balsaltic extrusives. The Rocky Mountains were formed of upfaulted, massive limestones, quartzites and other sediments of Devonian and Cambrian ages, with some intercalated volcanic rocks such as basalts and andesite. The Rocky Mountain Trench is a long valley of approximately the same length as the mountains and consists of undivided Paleozoics of various ages covered with alluvial deposits.

The Interior System of the Western Cordillera consists of the Selwyn Fold Belt, the Tintina Trench, and the Omineca Crystalline Belt. It stretches northwest 1,300 miles from the forty-ninth parellel with an average width of 200 miles.

The Omineca Crystalline Belt is composed of the Omineca and Cassiar Mountain ranges. The Omineca Mountains comprise two ranges: the Finlay and Swannell Ranges. The Finlay Ranges are composed mainly of Pre-Cambrian and Paleozoic sedimentary rocks, with areas of Mesozoic strata along their west flank. The Swannell Ranges, west of the Finlay Ranges, are extremely rugged, and are mainly composed of a granitic batholith flanked by Mesozoic and Upper Paleozoic strata on the west and by Mesozoic, Paleozoic and Pre-Cambrian strata on the east. The Cassiar Mountains are the northward extension of the Omineca Mountains. The Kechika Ranges along the western edge of the Rocky Mountain Trench are composed of sedimentary rocks, mainly of Paleozoic age.

LEGEND

1 Western Cordillera
- A. Northern Yukon Fold Belt
- B Mackenzie Fold Belt
- C. Selwyn Fold Belt
- D. Tintina Trench
- E Omineca Crystalline Belt
- F Rocky Mountain Thrust Belt
- G Rocky Mountain Trench

2 Interior Platform
- A. Northern Interior Platform
- B Southern Interior Platform

3 Canadian Shield
- A Bear Province
  - A1 Coppermine Homocline
  - A2 Wopmay Belt
- B Slave Province
- C. East Arm Fold Belt
- D. Churchill Province
- E Athabasca Plate

4 Arctic Continental Shelf

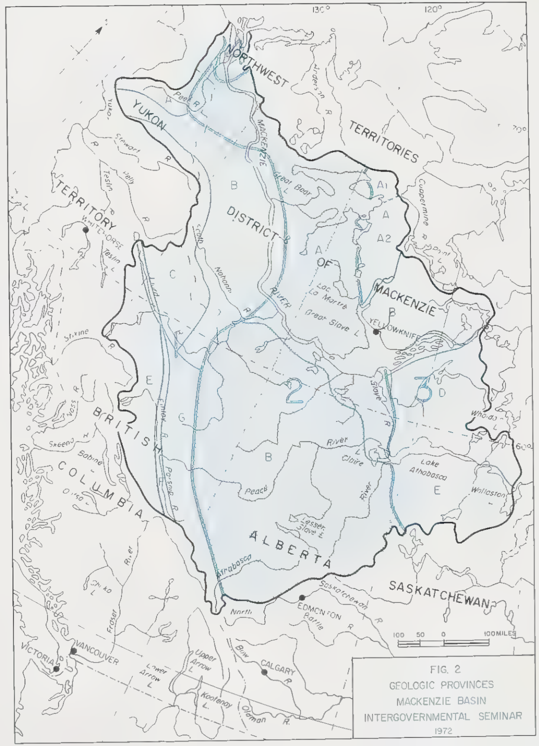


FIG. 2
GEOLOGIC PROVINCES
MACKENZIE BASIN
INTERGOVERNMENTAL SEMINAR
1972

The Selwyn Fold Belt consists of the Selwyn and Ogilvie Mountains, Liard Plain, Hyland Plateau and the Eastern Yukon Plateau. The Liard Plain is an area of low, wooded hills, underlain by Paleozoic sedimentary rocks; in places the exposed surface is composed of Tertiary lavas and carbonate bearing strata. The greater part of the Plain is mantled by thick deposits of glacial drift. The Hyland Plateau, an area of rolling hills and broad valleys, consists largely of Paleozoic sediments of Devonian age, interbedded with volcanics. The Selwyn Mountains are divided into the Logan Mountains south of Ross River, the Hess Mountains west of the Logans and the Wernecke Mountains to the northwest. These three ranges are formed of rocks similar to those in the Mackenzie Mountains: Pre-Cambrian, Paleozoic and Mesozoic strata and granitic batholiths. There is little layering apparent, due to the complex folding and faulting.

The Ogilvie Mountains, rising between Tintina Trench and Taiga Valley, are mainly Proterozoic sediments and volcanics along with Paleozoic, Mesozoic and Cenozoic intrusives.

The Tintina Trench, bisecting the Yukon Plateau, is composed of Cenozoic sediments including some early Tertiary carbonates in the northwestern part.

2.2 The Interior Platform

The Interior Platform is bordered on the west by the Western Cordillera and on the east by the Canadian Shield. The eastern border runs generally northwest-southeast through the middle of the three major lakes: Great Bear Lake, Great Slave Lake, and Lake Athabasca.

The Platform is underlain by Proterozoic sedimentary rocks which are nearly horizontal. A thick mantle of glacial drift forms the surficial features of plains and plateaus. The Platform may be divided into southern and northern sections, this division occurring at the northern flanks of the Cameron Hills and the Caribou Mountains. The southern part is composed of a relatively thick blanket of Mesozoic (Cretaceous age), and Cenozoic (Tertiary age) clastic rocks that overlie carbonate sediments and evaporites of the Paleozoic era. They rest on a basement of Pre-Cambrian sedimentary rocks of the Proterozoic and Archean ages.

The northern section of the Interior Platform is divisible into smaller units than the southern section. Devonian and older clastics, carbonate sediments and evaporites lie on Pre-Cambrian sedimentary and crystalline rocks and are covered by a thin veneer of late Lower Cretaceous rocks.

The Anderson Plain, lying in the northwestern section, is underlain by Mesozoic strata of the Cretaceous age, as is the southwestern part of the Peel Plain. The remainder of this Plain, as well as the Horton Plain and the Colville Hills are composed of undivided Paleozoics. The Peel Plateau rises in a series of upfaulted beds of Paleozoic and Mesozoic strata between Peel Plain and the Mackenzie Mountains.

Great Bear Plain is an island of Mesozoic strata mainly of Cretaceous age (sandstones and shales). In contrast, Great Slave Plain is largely underlain by Paleozoic sediments although the central portion, the Horn Plateau, was formed by the deposition of a layer of Cretaceous sandstones and shales. Except for these areas, Devonian limestones and shales form a broad belt of underlying strata stretching from Lake Athabasca northward to the Anderson Plain.

To the south and southwest, massive horizontal beds of Cretaceous sediments rest upon Devonian sediments and occupy nearly the whole of the Peace River Lowland, and northward up the Fort Nelson Lowland to the Liard River, i.e. most of the Alberta Plateau.

A few small areas of Tertiary sandstones and clays are found along the Pembina and the Great Bear Rivers and overlie some of the Cretaceous sediments in the Alberta Plateau, thus forming the Birch and Caribou Mountains.

2.3 The Canadian Shield

The eastern portion of the Mackenzie River Basin is a part of the Canadian Shield (Fig. 2). Its smooth, even horizon indicates an old, almost all-subduing erosion surface which at one time was at least in part buried under Paleozoic strata. The geologic time scale includes the development and partial dissection of a peneplain on the Archean rocks during Proterozoic times and then the subsequent burial and exhumation of this surface once, or perhaps twice during the Paleozoic era. Finally the area was scoured during the stages of Pleistocene glaciation.

The Shield is composed of the Bear and Slave Provinces on the eastern side of the two lakes, and the Churchill Province, the largest of the three, lying to the southeast.

The Bear Province is divided into the Wopmay Belt which consists of four groups of Pre-Cambrian sediments intruded by Proterozoic granites, and includes quartzite, dolomite and shale, and the Coppermine Homocline which consists of gently folded, northward tipping sediments intruded by gabbro sills and dykes.

The Slave Province is composed of Archean pyroclastics, greywacke and shale which have been overlain by rocks of the Yellowknife Period consisting of volcanics and

GEOLOGY

Geologic Division	Length (miles)	Width (miles)	Structural Formation
WESTERN CORDILLERA	1650	350-400	Folded, warped, uplifted and eroded series of ranges and valleys and plateaux. Sedimentary strata with massive metamorphics intruded by igneous rocks.
Northern Yukon Fold Belt	235	160	Folded and faulted Cretaceous (Mesozoic) strata overlie Paleozoic and Proterozoic rocks. Consists of Richardson Mountains, Old Crow Range and Porcupine Plateau.
Richardson Mountains	175	40	A straight, narrow belt of late Mesozoic sedimentary sandstones and shales overlying Devonian sandstones and quartzites.
Mackenzie Fold Belt	625	75-175	Composed of broad short folds of Devonian sediments faulted; overlying older carbonate-bearing Paleozoic strata. Made up of Liard Plateau, Franklin Mountains, Mackenzie Plain, and Mackenzie Mountains.
Liard Plateau	150	85	Broad plateau of Paleozoic and Mesozoic sediments.
Franklin Mountains	350	30	Consists of four ranges: Nahanni, Camsell, Norman and McConnell. Composed of Devonian sandstones, Cambrian shales, volcanics, limestones, and conglomerates.
Mackenzie Plain	400	15-60	Folded Cretaceous and Tertiary strata in north and in the south an anticline of Paleozoic rocks.
Mackenzie Mountains	525	60	Two ranges: Canyon Range — composed of Devonian shales and sandstones; and Backbone Range — composed of metamorphics and Paleozoic carbonate sediments.
Rocky Mountain Thrust Belt	900	60-100	Composed of: the main and westernmost ranges of Paleozoic and Proterozoic formations; the more easterly ranges of the Rockies formed of Paleozoic and early Mesozoic strata; and the Foothills underlain mainly by Mesozoic strata with outliers of Tertiary and inliers of Paleozoic rocks.
Rocky Mountain Foothills	900	15-40	Folded parallel belts of soft Cretaceous or Tertiary sandstones.
Rocky Mountains	900	50-85	Series of ranges of faulted, massive Devonian limestones, and Cambrian quartzites.
Rocky Mountain Trench	900	2-10	Undivided Paleozoics overlain by alluvial deposits.
Selwyn Fold Belt	525	150	Composed of broad folds of Paleozoic sediments; structures cut by plutonic rocks of Mesozoic age. Consists of the Ogilvie Mountains, Liard Plain, Hyland Plateau, Selwyn Mountains and the Eastern Yukon Plateau.
Liard Plain	165	25-110	Underlain by Paleozoic sediments which are overlain by Tertiary lavas and limestones, upon which glacial drift 200 feet thick has been deposited.

FACT SHEET NO. 2: GEOLOGIC FEATURES OF THE BASIN

GEOLOGY (cont'd)

Geologic Division	Length (miles)	Width (miles)	Structural Formation
Hyland Plateau	85	80	Paleozoic sediments (Devonian) interbedded by volcanics. All sediments covered by a layer of glacial drift.
Selwyn Mountains	260	45-90	Composed of three ranges: Logan Mountains, Hess Mountains, and Wernecke Mountains. Basically Precambrian, Paleozoic and Mesozoic rocks along with granitic intrusives.
Ogilvie Mountains	200	NW 160 SE-40	Northwest: mainly Proterozoic sediments overlain by Mesozoic sediments. Southeast: granites and volcanics interbedded with sedimentary shales.
Omineca Crystalline Belt	500	30-85	A granite batholith running parallel to the Rocky Mountain Trench, including extensive areas of metamorphics, and form the Omineca and Cassian Mountains.
Omineca Mountains	190	30-75	Two ranges: Finlay Ranges — Precambrian and Paleozoic sedimentary rocks, with areas of Mesozoic strata along the western flank. Swannell Range — mainly composed of the granite batholith.
Cassiar Mountains	300	35-85	Northward continuation of the Omineca Mountains. Precambrian bedrock overlain by Paleozoic sandstones and limestones and Mesozoic strata.
Tintina Trench	350	3-8	Composed of Cenozoic sediments; greater part of valley covered with gravel, sand and clay showing some degree of consolidation. Some early Tertiary carbonate rocks present in the north.
INTERIOR PLATFORM	1350	450 maximum	Bordered on the west by the Cordilleran Orogen and on the east by the Precambrian Shield. Underlain by Phanerozoic sediments; nearly horizontal beds covered by a thick mantle of glacial drift to form plains and plateaux of the Physiographic province, the Interior Platform. Divided into two regions: northern and southern. Division at Cameron Hills and Caribou Mountains. Southern: Relatively thick beds of Mesozoic and Tertiary clastic rocks overlying carbonate rocks and evaporites of early Paleozoic age which rest on a basement of Precambrian crystalline rocks. Northern: Devonian and older clastics carbonates and evaporites lie on Precambrian sedimentary and crystalline rocks and are covered in places by a thin veneer of late Lower Cretaceous rocks.
Anderson Plain	300	40-220	Surface is formed by horizontal beds of Mesozoic strata.
Peel Plain	220	35-70	Southwestern part basically Cretaceous sedimentary, horizontal beds; whereas in the northeast, undivided Paleozoic strata form partially folded hills.

GEOLOGY (cont'd)

Geologic Division	Length (miles)	Width (miles)	Structural Formation
Peel Plateau	215	20-125	Rises in a series of upfaulted beds of Paleozoic and Cretaceous sediments; southwest covered by a thin veneer of glacial drift.
Colville Hills	125	25-75	A series of anticlinal Paleozoic strata.
Great Bear Plain	280	120-220	An island of Mesozoic strata generally below 1000 feet elevation with several plateaux and hills rising to 1500 feet.
Great Slave Plain	575	35-235	Surface less than 1000 feet elevation; formed of Paleozoic strata; the Horn Plateau, an outlier of the Alberta Plateau, consists of a layer of Cretaceous sandstone rising to 1500 feet elevation.
Alberta Plateau	525	215-390	Devonian limestones and shales overlain by horizontal beds of Cretaceous sediments. Made up of a series of plateaux separated by wide valleys. Caribou Mountains and Cameron Hills form disconnected shape of Tertiary sandstones and clays rising between 2500 and 3700 feet elevation. 50% of area occupied by Fort Nelson and Peace River Lowlands; flat beds of Cretaceous sediments overlain by alluvium. Valleys bottoms rise from 1000 feet in the north to 2500 feet in the west.
Alberta Plain	500	225-400	South of Athabasca River; largely Mesozoic sediments but with some Tertiary shales in the west and south.
Saskatchewan Plain	700	50-325	Eastern border; The Missouri Coteau of Tertiary sediments. Plain composed of flat Mesozoic sedimentary beds, elevation 1500-2000 feet.
PRECAMBRIAN SHIELD	850		Smooth, even horizon – old erosion surface on massive Precambrian crystalline rocks, surrounded by a crescent of younger, stratified rocks. Occupies only the eastern edge of the Mackenzie Basin.
Bear Province	325	35-200	Mainly massive Precambrian sediments, volcanics and intruded by granites.
Slave Province	360	185-285	Comprised of Archean pyroclastics, greywacke and shale overlain by volcanics and sedimentary dolomites and limestones of the Yellowknife Period. Folded, metamorphosed and interbedded by granites and basalts.
East Arm Fold Belt	165	20-50	Archean rocks of the Wilson Island Group and the Kenoran period Granitics. Basically black and grey shale, basalt, dolomite, and greywacke. These overlain by a series of shale, siltstone, carbonate rocks and several thousand feet of conglomerate and sandstone.
Kazan Upland	640	485-600	Archean volcanics and pyroclastics overlain by Aphebian sediments of dolomite, siltstone and shale. Folded, metamorphosed and intruded by granites and gneisses.

FACT SHEET NO. 2: GEOLOGIC FEATURES OF THE BASIN

GEOLOGY (cont'd)

Geologic Division	Length (miles)	Width (miles)	Structural Formation
			Proterozoic sediments (sandstones and shales) deposited on top and extruded by basalts and other volcanics.
Athabasca Plate	160	260	Formed during Precambrian age as an original non-marine sediment. Subsequently overlain by Carswell and Martin formation during the Kenoran orogen; fluviomarine sediments.
			Predominantly sandstone with minor shale and conglomerate beds overlain by a dolomite sequence.
Arctic Continental Shelf	300	100	Bordering the Arctic Coastal Plain and the Mackenzie Delta. Little known of geology.
Arctic Coastal Plain	extends inland 6 to 12 miles		Cenozoic strata overlain by Pleistocene glacial drift and alluvium.
Mackenzie Delta	150	50-100	Cretaceous and Cenozoic rocks overlain by alluvium and glacial drift.

GEOLOGICAL TIME CHART			Millions of Years before Present
CENOZOIC	QUATERNARY		1
CENOZOIC	TERTIARY	PILOCENE	11
CENOZOIC	TERTIARY	MIOCENE	25
CENOZOIC	TERTIARY	OLIGOCENE	40
CENOZOIC	TERTIARY	EOCENE	60
CENOZOIC	TERTIARY	PALEOCENE	70
MESOZOIC	CRETACEOUS		135
MESOZOIC	JURASSIC		180
MESOZOIC	TRIASSIC		225
PALEOZOIC	PERMIAN		270
PALEOZOIC	CARBONIFEROUS		350
PALEOZOIC	DEVONIAN		400
PALEOZOIC	SILURIAN		440
PALEOZOIC	ORDOVICIAN		500
PALEOZOIC	CAMBRIAN		600
PROTEROZOIC			2400
ARCHAEOZOIC			3000
AZOIC			3500

FACT SHEET NO. 2: GEOLOGIC FEATURES OF THE BASIN

sediments (dolomite, limestone). These in turn were folded and metamorphosed and intruded by granites which underlie two-thirds of the Province.

The Churchill Province is comprised of three regions, the East Arm Fold Belt, the Kazan Upland and the Athabasca Plate.

The East Arm Fold Belt is composed of low grade metamorphic rocks, generally tilted or gently folded Archean sediments, intruded by gabbro sills and diabase dykes overlain by a series of shales and greywackes.

The Kazan Upland includes rocks of the Archean age (volcanics and pyroclastics) which have been overlain by Aphebian sediments (dolomite, siltstone, shale). These rocks have been folded and metamorphosed and then intruded by granites and granitic gneisses. Proterozoic sediments (sandstones and shales) were deposited on top of them and were subsequently overlain by basalts and other volcanic rocks.

The Athabasca Plate was formed during Pre-Cambrian time and is the largest marine sedimentary outlier in the Shield. The formation covers an area of 40,000 square miles in northern Saskatchewan and consists predominantly of sandstone with minor shale and conglomerate beds.

2.4 Arctic Continental Shelf

The Arctic Coastal Plain extends beneath sea level to merge with the Arctic Continental Shelf (Fig.2). Little is known about the geology of the Arctic Continental Shelf which extends approximately 100 miles north of the mainland and then breaks away rapidly to an irregular continental slope beneath the Beaufort Sea. The mainland part of the Arctic Coastal Plain comprises the Cretaceous and Cenozoic rocks of the Mackenzie Delta and a narrow belt, the Yukon Coastal Plain, that truncates the Richardson Mountains or borders the British Mountains.

3. GEOGRAPHY OF THE BASIN

3.1 Physiography

The physiography of the Basin can be divided into three distinct regions, each with its own characteristics. These are, from east to west, the Pre-Cambrian Shield, the Interior Plain and the Western Cordillera regions (Fig. 3).

The Shield

This region lies east of an arc running through the east end of Great Bear Lake, the center of Great Slave Lake and the west end of Lake Athabasca. The arc delineates the contact zone between the predominantly crystalline and metamorphic shield rocks and the sedimentary strata underlying the Interior Plain. Ages of erosion have levelled the shield to a nearly featureless, rocky plain, a mosaic of lakes interspersed with ridges and hummocks of glacial till. River valleys are not well defined and the drainage system is confused. However, several distinct areas within the shield can be distinguished, based mainly upon geological variations.

South of Lake Athabasca lies the Athabasca Plain, an area of nearly flat lying, unmetamorphosed sandstones rising from 900 feet elevation in the west to 2,000 feet in the east. Drainage from the area is almost entirely into Lake Athabasca. Northwards, the Basin includes portions of the Kazan and Bear-Slave Uplands. These areas are treeless, massive rock batholiths with an elevation of from 1,000 to 2,000 feet and are covered with numerous lakes. The East Arm Hills, an area of faulted and folded sediments surrounding the east arm of Great Slave Lake, separates the two uplands. Northeast of Great Bear Lake, a small region of sedimentary rock forms a broad upland, 2,000 feet in elevation. This region is part of the Coronation Hills.

The Interior Plain

The Interior Plain covers almost one-third of the Basin, and may be divided into at least two distinct regions. Most of the Interior Plain within the Basin south of the 60th parallel is part of the Alberta Plateau. The Cameron Hills and the Caribou Mountains form a high, disconnected escarpment with summits between 2,500 and 3,200 feet overlooking the Great Slave Plain to the north. To the east and south the Alberta Plateau extends along the flanks of hills north of the Athabasca River and overlooks the Alberta and Saskatchewan Plains, small portions of which lie within the Basin. Two valleys, the Fort Nelson and Peace River Lowlands, occupy more than half of the Alberta Plateau. They rise from 1,000 feet in the north and northeast to 2,500 feet in the west.

Another distinct region of the Interior Plain is the Great Slave Plain, which is part of the larger Mackenzie Lowland area. It is characterized by generally low relief, below 1,000 feet in elevation. An exception is the Horn Plateau in the central part of the Plain which rises to 2,500 feet. The northern boundary of the Great Slave Plain is marked by the south-facing escarpment of the Cartridge Mountains.

Between the Great Bear Plain and Mackenzie Delta along the east bank of the Mackenzie River lie small portions of the Colville Hills and the Anderson Plain. To the west the Peel Plain and the Peel Plateau occupy a large triangular-shaped terrace north of the Mackenzie Mountains and east of the Richardson Mountains. The land rises in

LEGEND

1 Western Cordillera
- Richardson Mountains
- Porcupine Plateau
- Taiga Ranges
- Ogilvie Mountains
- Wernecke Mountains
- Selwyn Mountains
- Mackenzie Mountains
- Mackenzie Plain
- Franklin Mountains
- 10 Yukon Plateau
- [illegible]
- 12 Cassiar Mountains
- 13. Liard Plateau
- 14 Hyland Plateau
- 15. Liard Plain
- 16 Rocky Mountains
- 17 N Rocky Mountains Trench
- 18 Rocky Mountain Foothills
- 19 Omineca Mountains

2 Interior Plain
- 1 Mackenzie Delta
- Peel Plateau
- Peel Plain
- Anderson Plain
- Colville Hills
- Great Bear Plain
- Horn Plateau
- Great Slave Plain
- Cameron Hills
- 10 Caribou Mountains
- 11. Fort Nelson Lowland
- 12 Peace River Lowland
- 13 Alberta Plateau
- 14 Alberta Plain
- 15 Saskatchewan Plain

3 Canadian Shield
- 1 Coronation Hills
- 2. Bear–Slave Upland
- 3 East Arm Hills
- 4 Kazan Upland
- 5 Athabasca Plain

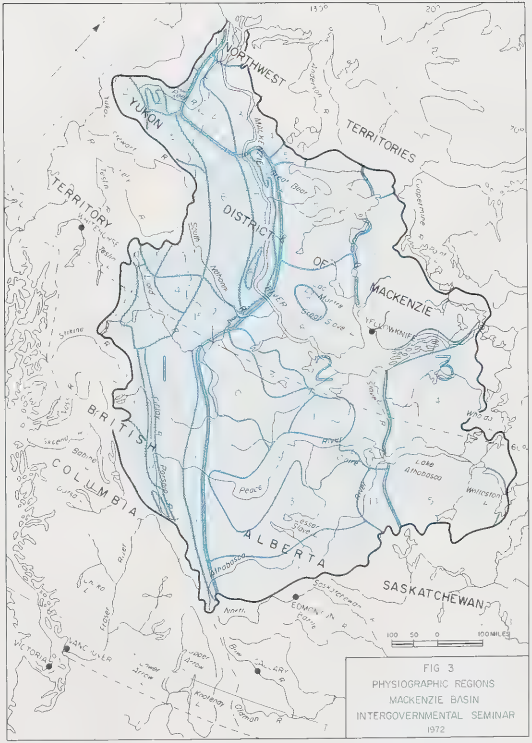


FIG 3
PHYSIOGRAPHIC REGIONS
MACKENZIE BASIN
INTERGOVERNMENTAL SEMINAR
1972

several steps towards the mountains, broken by the broad, shallow Peel River Valley.

The Arctic Coastal Plain, a northern extension of the Interior Plain, merges with the Arctic Continental Shelf and extends approximately 100 miles to the North. On the mainland, the Arctic Coastal Plain consists of the Mackenzie Delta and the Yukon Coastal Plain. The Mackenzie Delta has a compound character and includes not only the delta of the present river but remnants of earlier deltas and complex fluviatile-marine features such as Cape Bathurst. The outstanding features of the delta plain are its multitude of lakes and channels and its pingos. Immediately west of the mouth of the Mackenzie River, the Yukon Coastal Plain, considerably higher than the Delta, forms the extreme northwestern boundary of the Mackenzie River Basin.

The Cordillera

Most of the Eastern System of the Cordillera north of the Athabasca headwaters lies within the Mackenzie River Basin. The Rocky Mountains and the foothills paralleling their eastern front extend northwest as a near-continuous wall until they are sharply severed by the Liard River Valley close to the 60th parallel. Their eastern boundary is approximated by plotting an imaginary line through Calgary, Alberta, and Hudson Hope, B.C. The tributaries of the Peace River – the Finlay, Omineca and Parsnip Rivers – rise immediately to the west in the Omineca Mountains of the Interior System.

Separating the Rocky Mountains from the Mackenzie Mountains to the north is a region of hills mostly under 4,500 feet known as the Liard Plateau. The Hyland Plateau includes a series of hills rising to 4,000 feet, which lie to the west of the Liard Plateau. The Cassiar Mountains, south and west of the Liard Plain, form the extreme western boundary of the Liard Basin.

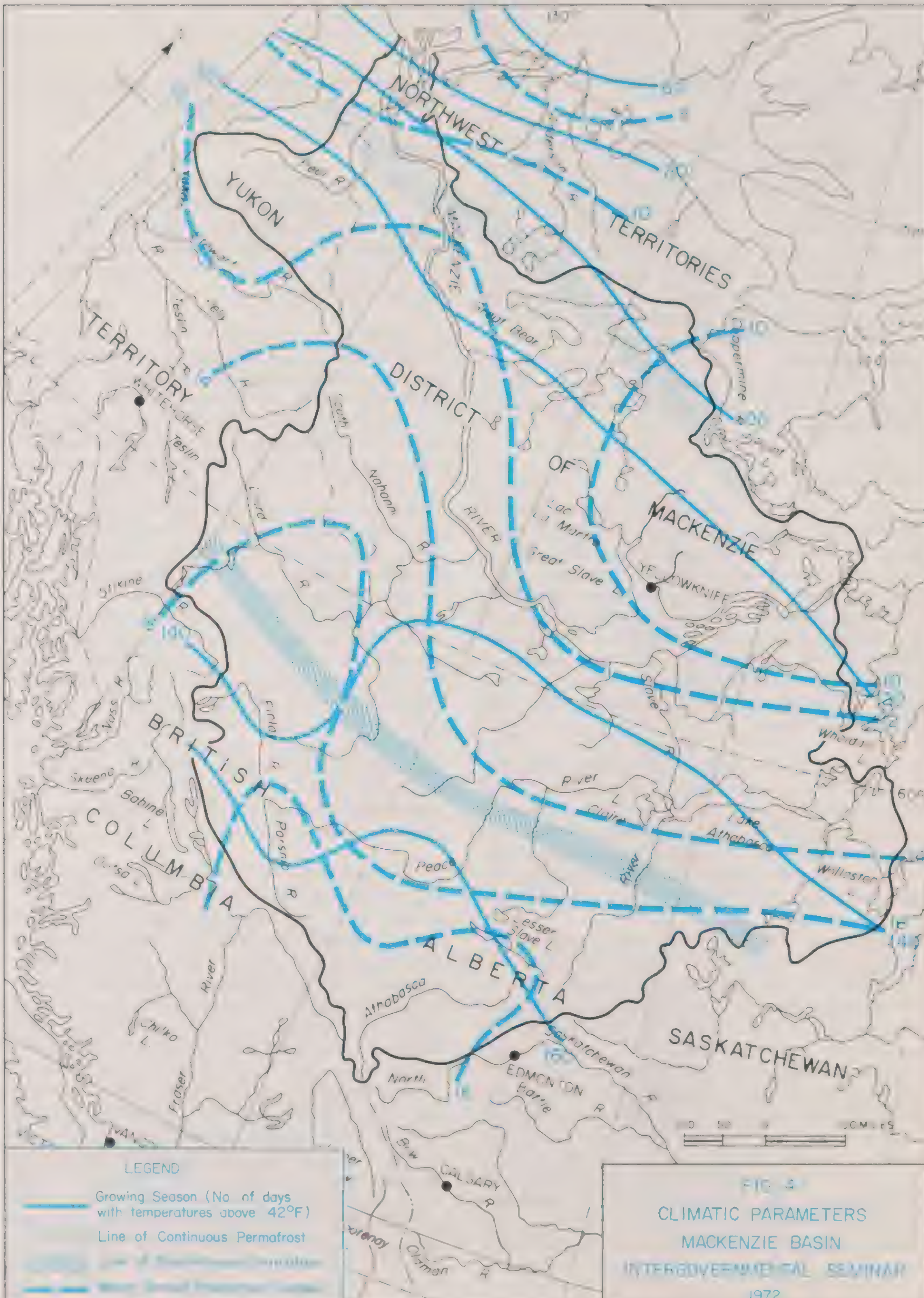
North of the Liard Plateau, the eastern boundary of the Cordillera runs north and west in a sweeping curve that includes the Franklin Mountains along the eastern bank of the Mackenzie River. This low, narrow range is separated from the Mackenzie Mountains by the Mackenzie Plain, an isolated strip of the Interior Plain which forms a portion of the Mackenzie River Valley. Within the interior portion of the Mackenzie Mountains, the rugged Backbone Ranges rise to 8,500 feet above sea level, while the eastern portion (the Canyon Ranges) are more rounded and rise to a lower elevation. The Peel Plateau, traversed by the Peel River, separates the Mackenzie Mountains from the Richardson Mountains, the narrow range which forms the remainder of the western part of the Basin boundary north to the Arctic coast. Tributaries of the Peel River rise in the western extension of the Mackenzie Mountain area composed of the Wernecke, Taiga and Ogilvie Mountains.

3.2 Climate

The climate of the Mackenzie Basin may be divided into two regimes – tundra and sub-arctic. The tundra climate embraces the northeastern part of the basin as well as the higher altitudes of the Western Cordillera. The remainder of the basin is sub-arctic in nature with low precipitation and cool summers (Figs. 4 and 5).

In the region north of the Arctic Circle ($66^1/_2{}^\circ$N) which includes approximately one-quarter of the Mackenzie Basin, there is a period in the winter when the sun is continuously below the horizon. The length of this dark period varies from one day at the Arctic Circle to six months at the North Pole. Since no direct solar radiation is received during this dark period, the ground radiates heat into space, the air grows colder and denser, and the atmospheric pressure begins to build. The centre of highest pressure usually situates itself over the Central Mackenzie Valley although it does not always remain within fixed boundaries. Throughout the winter, surges of cold air flood southward at intervals into the lower Mackenzie Valley and onto the centre of the continent carrying arctic conditions as far south as the Great Plains. Very low temperatures prevail during the winter months in the Mackenzie Basin. With no significant source of heat available, temperatures often drop to -60°F and may recover to only -40°F to -50°F during the daily twilight period. Such spells of intense cold may last for several weeks at a time, particularly during the months of January and February. The ability of the air to contain moisture at such low temperatures is limited and very little precipitation can fall under such circumstances.

The southern part of the Mackenzie Basin usually does not endure such long, unbroken spells of clear, cold weather. More likely, the general pattern of weather will reflect brief alterations from cold, clear air to cloudy, modified air that is periodically drawn across the Cordillera from the Pacific. Typically, such a weather regime gives rise to heavier winter precipitation than can be expected farther north. These changes in contrasting weather patterns are a function of a more disturbed pressure field than is typical farther north. Low pressure system originating in the Gulf of Alaska frequently cross the Rocky Mountains between 50°N and 60°N bringing with them modified air masses from the Pacific Ocean. Their period of influence is brief, though, as the colder air gains southward momentum behind the passing low pressure centres. Strong and shifting winds accompany these major weather changes across Northern Alberta. On occasion, a combination of high winds and loose snow creates a heavy blowing snow



CLIMATIC PARAMETERS
MACKENZIE BASIN
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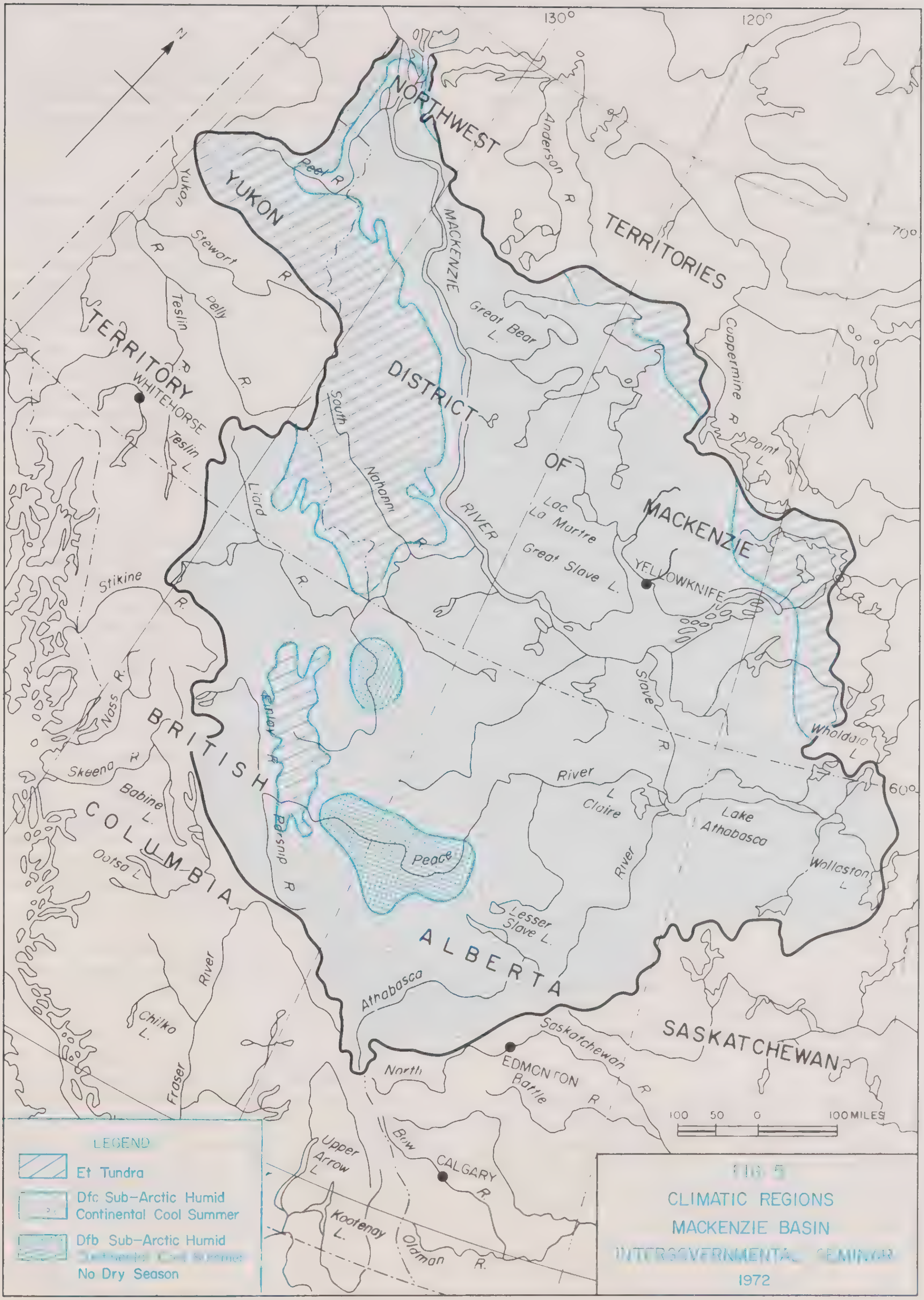

FIG. 5
CLIMATIC REGIONS
MACKENZIE BASIN
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condition which can seriously disrupt most means of transportation. Ironically, too, human discomfort from the cold can be made much more noticeable in the southern sections of the Basin than in the north because of the wind factor. The strong, cold winds can produce temperature sensations on exposed flesh which far exceed (in the negative sense) any real temperature values recorded a thousand or more miles to the north. On one occasion at Edmonton, the wind chill approached −100°F, a value which is some 20°F lower than the lowest officially recorded temperature in Canada (−81°F at Snag, Yukon).

Once the sun reappears above the horizon in February and March, increasingly significant amounts of heat begin to modify the cold air centre and slowly the ridge of high pressure begins to erode. As temperatures moderate, increased storminess develops through the Central and Northern Mackenzie Basin and the long winter drought finally breaks. As the spring season advances, the storms move farther north and melting conditions advance slowly down the valley. By June, most of the snow has melted in the northern sections though lake ice may persist until the end of the month. In the south, the summer season is warm and convective showers and thundershowers are common. This phenomenon does not extend much above 65°N as the atmosphere tends to be more highly stratified to the north. Near the arctic coast, most summer rains develop around weak lows travelling southeast from the Beaufort Sea or from stratus or stratocumulus layers drifting onshore from the Arctic Ocean. At this same latitude, rather spectacular temperature changes can occur with slight changes in wind direction. A southerly breeze can often carry very warm air northward from the Prairies and send temperatures close to 90°F as far north as Inuvik. A change to a northerly breeze, by sharp contrast, can carry cold air off the arctic ice packs onto the coast causing a 30° to 40°F drop in temperature in just a few hours.

With the advance of the autumn season, the greater obliquity of the sun's rays possesses smaller heating capabilities and the air over the northern Mackenzie Basin begins to grow colder again. Interaction between this cold air and the still warm air masses to the south increases the incidence of storminess and eventually the rains turn to snow as the cold air entraining into the migratory lows continues to chill.

Easterly winds circulating around the low pressure systems will have a significant vertical component as they are forced to ascend the higher terrain. Upslope flow will nearly always enhance the condensation process and result in heavier precipitation regimes than would otherwise occur. Figure 4 indicates that precipitation values are higher west of the Mackenzie River than east of it.

As the arctic air acquires dominance by late December or early January, the weather patterns become more settled and a generally clear, cold regime takes over until spring.

3.3 Permafrost

Approximately one-half of Canada lies in the permafrost region. Most of the Basin, except for the portion below 56° – 57°N latitude, is included within this zone. Permafrost may be divided into two zones: a continuous zone where permafrost appears everywhere beneath the ground except in newly deposited unconsolidated sediments, and a discontinuous zone to the south, where it is confined to peatlands, north-facing slopes of east-west oriented valleys, and isolated patches of forested stream banks. A surface layer of soil or bare rock is found above the permafrost and may be called the active layer, which thaws in summer and freezes in winter. Its thickness depends upon the same climatic and terrain features that affect the development of permafrost.

The thickness of permafrost varies from 200 feet at the southern limit of the continuous zone and increases to 1,000 feet in the northern part of the zone. The depth of the active layer is $1^1/_2$ to 3 feet. In the discontinuous zone the permafrost zone varies from a few inches in the south to 200 feet in the north and the depth of the active layer may vary from 2 to 10 feet depending upon local climatic and terrain conditions. In the Cordillera the distribution of permafrost varies with elevation as well as with latitude.

Climate and terrain are the two major factors that affect the distribution and development of permafrost in all areas. The southern limit of permafrost coincides roughly with the 30°F mean annual air temperature isotherm. Between 25°F and 30°F permafrost is restricted to the drier portion of peatlands and peat bogs. The 17°F mean annual air temperature isotherm divides the continuous and discontinuous zones of permafrost and is equivalent to the 23°F mean annual ground temperature isotherm.

The second factor in permafrost development is terrain. Terrain is influenced by the following elements: relief, drainage, vegetation, snow cover, presence of fire, and soil and rock type.

Relief influences the amount of solar radiation received by the ground surface and the amount of snow accumulation. In the continuous zone, the permafrost is thicker and the active layer thinner because of the flat terrain. The insulating properties of moss and peat shield the permafrost from solar radiation. If vegetation is removed in the discontinuous zone, there may be a complete removal of permafrost. Permafrost is detrimental to plant development in that it retards root systems.

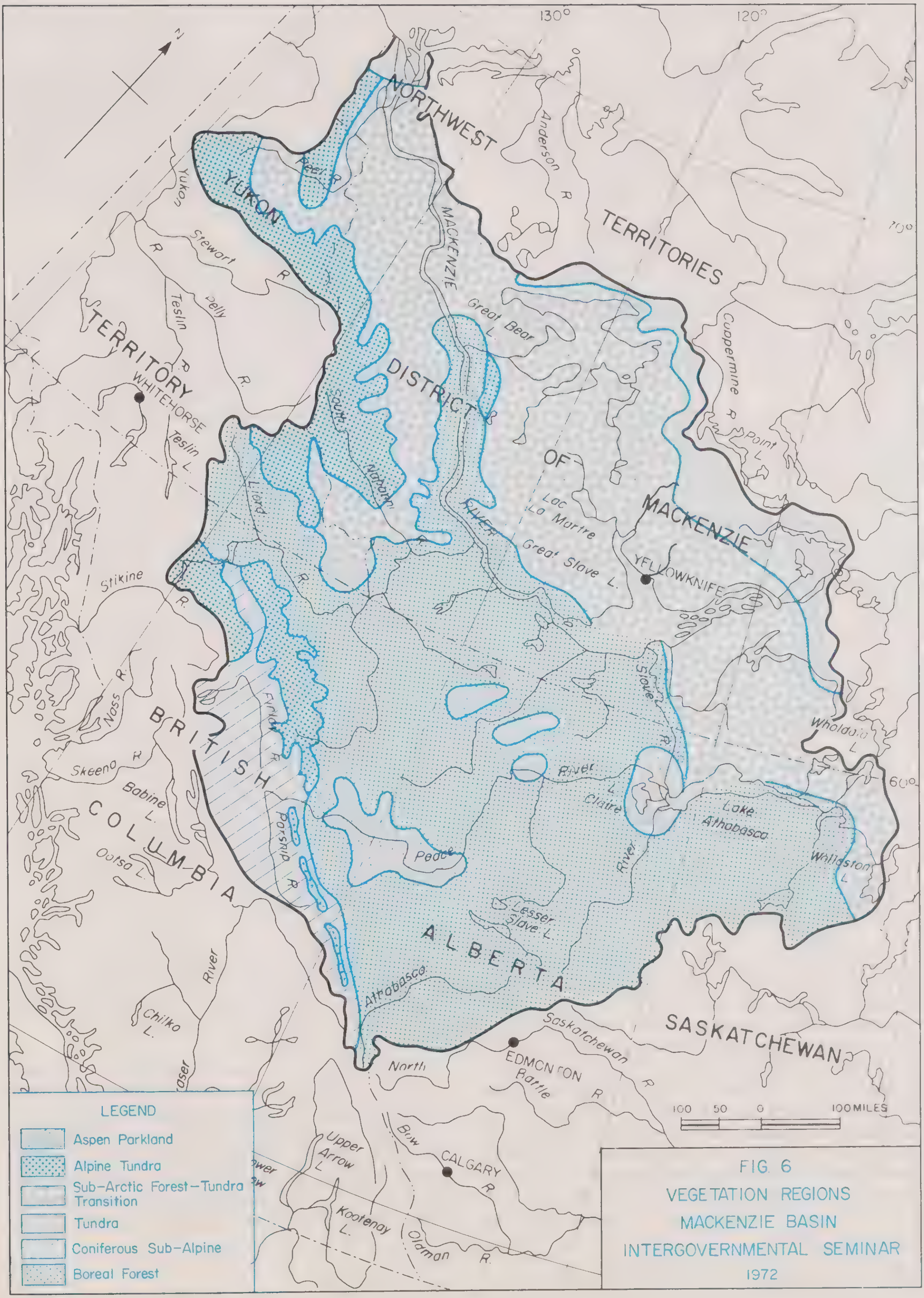


FIG. 6
VEGETATION REGIONS
MACKENZIE BASIN
INTERGOVERNMENTAL SEMINAR
1972

Drainage affects permafrost, in that moving water is a highly effective erosive agent of frozen ground and, in poorly drained areas, inhibits permafrost development. Precipitation also influences the depth of thaw and soil temperatures. Permafrost influences the hydrological regime because of its impermeability and is responsible for the existence of many shallow lakes and ponds.

It has been found that 16 inches of snow cover is the critical level for permafrost development and that above this level permafrost is not present or is in a condition of degradation. Permafrost is thickest in the continuous zone where there is thin snow cover due to small amounts of precipitation and surface wind conditions. The depth of snow cover will affect the depth of the active layer.

If fire penetrates the vegetation cover, degradation or complete removal of permafrost may occur in either zone due to the loss of peat and moss which act as an insulating layer between permafrost and climatic conditions.

Soil and rock type affect the permafrost layer as each type reflects varying amounts of solar radiation, which in turn influences ground temperatures that influence permafrost development.

3.4 Vegetation

The vegetation of the Mackenzie Basin varies from barren tundra in the extreme northeast to dense stands of spruce and pine in the boreal forest region of the south and southwest (Fig. 6).

Much of the Basin is covered by coniferous boreal forest, dominated by white and black spruce. In the eastern section of the boreal forest area, jack pine and tamarack are interspersed with spruce; in the west, alpine fir and lodgepole pine are found at the lower elevations of mountain slopes. In the south, spruce still predominates, but at the extreme edge of the Basin, white birch and balsam poplar occur in abundance.

Certain sections of the boreal forest region have vegetative characteristics peculiar to themselves. For instance, the Hay River section represents the northward extension of mixed wood forest which predominates south of the Northwest Territories. Black spruce is dominant throughout this region, with jack pine in the east and lodgepole pine in the western part. The Upper Mackenzie area contains white spruce and poplar on the alluvial flats bordering the rivers, with white birch stands on old levees. Above the floodplains, large areas of sandy soils support pines, aspen, and in some cases, tamarack. This section extends as far north as Great Bear Lake. Between Fort Smith and Great Slave Lake, the land adjacent to the Slave River supports large stands of white spruce; this is also true of floodplains of the Liard and Peace Rivers. Scattered stands of lodgepole pine, poplar, birch and spruce are found on sand terraces above the Liard River. The highlands bordering the Slave River are covered by jack pine interspersed with poplar, birch and spruce. Along the Mackenzie River benchlands, white and black spruce predominate.

The Lower Mackenzie River section from Great Bear Lake to the Mackenzie Delta is essentially a subarctic forest-tundra transition zone. The true boreal forest is found only along the alluvial flats and river banks. Where the land is well drained and the permafrost table is low, white spruce may be supported. Scrub willows and alders with stunted white and black spruce are found on fine-textured alluvial flats. On the upland sites, poplar has been superseded by white birch.

The Upper Liard section is the western fringe of the boreal forest. The plateaus above the river support lodgepole pine, white spruce, and aspen, while the alluvial flats support pure stands of white spruce and poplar. Above the floodplain, spruce, pine, aspen and fir are found near the tree line.

The subarctic forest and tundra transition zone includes most of the area around eastern Great Slave Lake, Great Bear Lake and a western band along the Mackenzie Mountains. This zone represents the transition between tundra and mixed forest woodland, and is known as taiga. Thin soils and unfavourable climatic conditions support little but peat and muskeg. Good stands of black spruce and white birch exist in areas of deep, sheltered, frost-free soils. Most upland interfluves are a mosaic of barrens, with groups of stunted black spruce appearing only along the lake and river shores. The western section of this transition zone represents the transition between boreal forest and alpine tundra. Open, park-like stands of stunted white spruce alternate with patches of shrub vegetation or rocky barrens.

The Peace-Athabasca Delta, the Peace River Lowlands, and several small areas in northeastern Alberta are covered by Aspen Parkland. Groves of aspen poplars are interspersed with prairie grasses, and the stream valleys support dense stands of aspen and willow, and some conifers.

The irregular mountain topography of the Basin produces a great diversity of habitats and plant communities. Northern and easterly exposures tend to be cooler and more moist and as a result, support thick coniferous forests of Engelmann spruce, white spruce, and alpine fir below the tree line. Southern and westerly exposures, warmer and drier than northerly ones, support stands of Douglas fir and pine. At about 7,000 feet there is a gradual

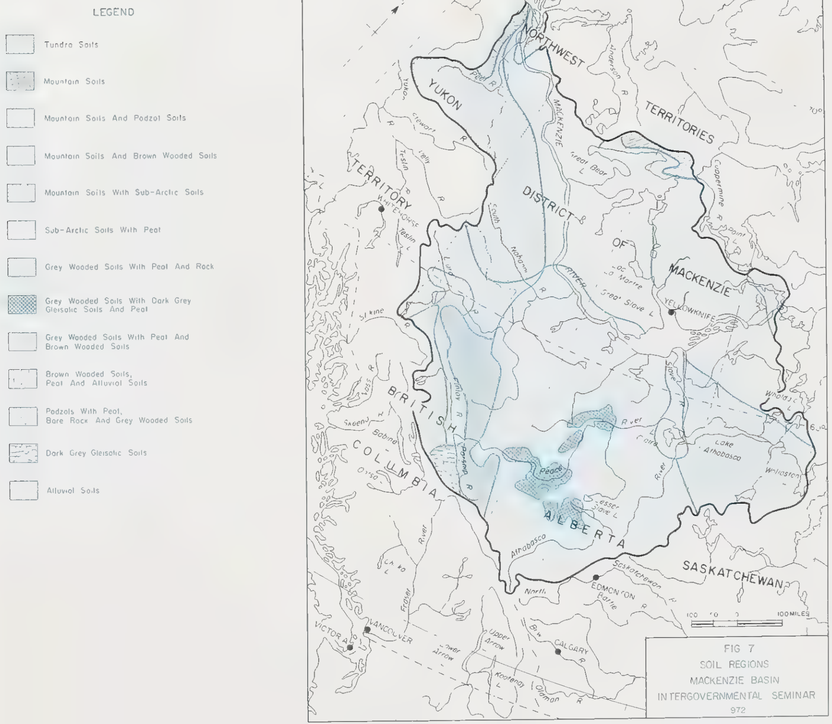


FIG 7
SOIL REGIONS
MACKENZIE BASIN
INTERGOVERNMENTAL SEMINAR
972

breaking up of the forests into tree "islands" and finally into isolated, dwarfed trees.

Alpine tundra ranges from 7,500-foot elevations to the barren rocky peaks of the mountains. A mean annual temperature of 25°F and a seven-day frost-free period influence plant development greatly. Here are found plant species such as the snow willow which is low-lying, drought and wind-resistant, and able to withstand deep snow cover.

The tundra area is mainly the flat-lying, undulating, treeless plain which we normally associate with the word "arctic". The word "tundra" is of Finnish origin and means open rolling plain or barren land. The tundra zone lies on the extreme northeastern edge of the Basin. There are only a few plant species which can survive the harsh environment. Five main groups are recognized: lichens, mosses, grasses, cushion plants and shrubs. Wild crocus, mountain avens, arctic poppy and saxifrage colour the tundra in summer. The tundra may be divided into several subdivisions, each with its own characteristic plant associations. These include sedge-grass tundra, heat tundra and moss-lichen tundra. The subdivisions are not clearly separated and plants may be influenced more by local than by regional conditions. Sedge-grass tundra covers the sediments of the Mackenzie Delta and dwarf shrub-heath tundra occupies the southerly part of the tundra nearest to the subarctic forest zone. Creeping willows, dwarf birches and other berry producing plants are interspersed with heather and mosses.

3.5 Soils

Although the effects of climate and vegetation may be fairly uniform over broad areas, local differences in parent materials and drainage have resulted in the formation of different soils. The soil groupings are based on the dominant occurrence of one particular group (Fig. 7).

The first group of soils is the Grey Wooded. These well drained to imperfectly drained soils are associated with coniferous-deciduous boreal forests and a subhumid climate. The parent material is usually neutral to alkaline in character and covered by an organic layer with an impoverished light-grey layer near or at the surface. Clay is the main soil constituent. Associated with the first group is an orthic Grey Wooded Soil which is characterized by a leaf mat, a thin dark surface of less than 2 inches in thickness and a light grey platy structured sub-surface horizon. This soil is low in natural fertility.

The Grey and Dark Grey Wooded Soils occur in the same area. They have a dark grey surface horizon of 3 to 10 inches in thickness and a very light-grey leached horizon.

Another group found in the Basin is the Grey-Brown Podzolic soils. This group has a grey layer near or at the surface, but instead of an enrichment of clay in the subsurface horizon, it has an accumulation of organic matter. The group can be drained or imperfectly drained and develops under coniferous and mixed forests but can exist further north in cold to temperate local climates. Accumulation of organic matter constitutes less than 30% of the subsurface horizon. These soils have pronounced horizons, extensive leaching, a greater moisture content and occur at higher elevations.

Another group common to the Basin is the Brunisolic Soils (Brown). For reasons associated with climate, with parent material or with age, these soils do not have the leached grey horizon or the enriched subsurface horizon of Luvisolic and Podzolic soils. They are of a brownish colour, with a weakly developed horizon and have good to imperfect drainage. They have developed under forest, mixed forest and grass, heat and tundra and alpine conditions. The Brown Wooded Soils are neutral to mildly alkaline in reaction and occur in the valleys of the Cordillera or in northern Alberta in conditions normally associated with Grey Wooded Soils. Acid Brown Wooded Soils are mildly to moderately acid in reaction and are found in forest-alpine transition zones.

The Gleisolic soils group is normally under reduction rather than oxidation and is saturated with water. They develop under hydrophytic vegetation and have an organic surface of less than 16 inches of mixed peat or up to 24 inches of peat moss. They may have developed horizons, but in most cases excessive water and lack of aeration have restricted development. Unlike the soils in previous orders the Gleisolic soils may differ markedly in their individual profile characteristics; the Humic Gleisols have dark coloured mineral-organic surface horizons and the Eluviated Gleisols have Podzolic features.

An integral part of the overall soil pattern of the Basin includes the Organic or Tundra soils. These widespread soils of the arctic region are mineral in character, underlain by permafrost, and very poorly drained; in fact they may be saturated for most of the year. The organic horizon at the surface is usually several inches thick and upper horizons tend to be strongly acid in reaction. The tundra soils are a northern counterpart of the Gleisolics. Northward of the forested areas the impermeable permafrost layer is close to the surface, resulting in a very high proportion of poorly drained land. The process of soil building weakens in extreme northern areas because of the reduced chemical and biological activity, short growing season and low temperatures.

Another Basin soil grouping is the Subarctic soils. These soils may be found south of the Tundra soils and north of

PHYSIOGRAPHY

- Divided into 3 distinct regions: Precambrian Shield, Interior Plain and Western Cordillera.

Canadian Shield

- Lies east of an arc running through east end of Great Bear Lake, centre of Great Slave Lake and west end of Lake Athabasca.
- Ages of erosion have levelled shield to a nearly featureless plain, a mosaic of lakes interspersed with ridges and hummocks of glacial till.

Sub-Divisions	*Areal Characteristics*
• Athabasca Plain	Has a rolling, hummocky, lake-spotted surface rising in elevation from 900 feet in the west to 2000 feet in the east and a local relief of 200 to 300 feet.
• Kazan Upland	A treeless, rolling, massive rock batholith with an elevation of 1000-2000 feet rising to 1500-1900 feet north of the Athabasca Plain.
• East Arm Hills	An area of down faulted, folded differentially eroded sediments and gabbro sills. North side dips to form broad cuestas 900 feet above Great Slave Lake. Most intervening valleys flooded by Great Slave Lake. South side hills narrower and lower.
• Bear-Slave Upland	A peneplain surface devoid of trees; numerous hollows filled by lakes and some rounded rocky hills with a relief of 100-200 feet. Many monadnocks exceeding 1000 feet in relief; summits reaching 1600 feet in elevation.
• Coronation Hills	A series of hills formed from anticlinal sediments; summits may reach 2000 feet in southwest.

Interior Plain

- Covers almost 1/3 of the Basin and may be divided into 2 regions at the 60th parallel.

Sub-Divisions	*Areal Characteristics*
• Anderson Plain	An undulating plain rising inland with large parts covered by glacier outwash and deeply entrenched by runoff channels.
• Peel Plain	Broad, shallow hollow about 400 feet in elevation and spotted with lakes. Arctic Red River entrenched in plain.
• Peel Plateau	Rises in a series of steps to the Mackenzie Mountains. First step a very flat surface followed by a flat terrace and on top of this a group of undulating, rounded plateaux. Separated from Mackenzie Mountains by a broad, shallow but poorly defined valley. Most of surface except southwest covered by thin layer of glacial drift with lakes lying in the hollows.
• Colville Hills	Remnants of large, entrenched meltwater channels cross plateau. A series of hills and ridges enclosing hollows with large lakes in a mesh pattern of 10 miles diameter. Elevations 2200 feet for hills and 800-1000 feet in hollows.
• Great Bear Plain	A rolling surface below 1000 feet elevation occupied in part by Great Bear Lake. A number of small, subcircular plateaux and hills (Scented Grass Hills) found in the Plain at 1500 feet elevation.
• Great Slave Plain	Separated from Great Bear Plain by escarpment called Cartridge Mountains; very flat plain with innumerable lakes. Centre of Plain occupied by Horn Plateau, an outlier of the Alberta Plateau.

PHYSIOGRAPHY (cont'd)

- **Alberta Plateau** — A ring of plateaux separated by broad, flat valleys. Cameron Hills and Caribou Mountains, a high disconnected escarpment 2500-3200 feet high. All uplands and plateaux (Birch Mountains, Muskeg Mountain, Utikuma Upland) have a smooth, flat surface. Fort Nelson and Peace River Lowlands form two valleys occupying 50% of the Plateau area. Very flat; covered with glacial drift and alluvium with rivers entrenched.

- **Alberta Plain** — A continuation of the Plateau but has a more even surface with a few widely separated groups of hills.

  Plain 2500 feet in elevation.

- **Saskatchewan Plain** — Separated from Alberta Plain by Missouri Coteau, a line of low, rounded hills graduating northward into the Plain.

  Gently undulating to rolling surface ranges from 1500 to 2600 feet above sea level and local relief of 300 feet in hillier areas.

Cordillera

- Forms a great wall between the Pacific Ocean and the Interior Plain.
- Generally runs northwest in a series of ranges and valleys for 1650 miles. Varies in width from 350 to 400 miles.
- Also divided transversely into a number of segments by east-west belts of relatively low terrain.

Sub-Divisions	*Areal Characteristics*
• Rocky Mountain Foothills	15-40 miles wide rising abruptly from the Interior Plain. Mainly composed of rounded hills although high ridges may be found on the western rim.
• Rocky Mountains	Mountains consist of ridges with a northwest alignment; highest in the north 10,500 feet elevation and subsiding to more subdued mountains of 6000 to 9000 feet elevation in south. Area greatly glaciated creating U-shaped valleys, cirques.
• Rocky Mountain Trench	Stretches more than 900 miles; relatively narrow, straight and steep-walled. Floor width varies from 2 to 10 miles, lying between 2000 and 3000 feet above the sea.
• Liard Plateau	An area of broad, even-topped ranges of hills rising to 4500 feet, separated by wide, rolling valleys draining southeastward. Slopes of much of the valleys have elevations of about 3000 feet and the valley floors 1500-2000 feet. Mantled with glacial and outwash deposits including a great compound esker creating a low ridge of about 200 feet.
• Franklin Mountains	The easternmost structure of the Cordillera. A series of four ranges: Nahanni Range — consists of two parallel ridges 6-10 miles wide at an elevation of 5000 feet; Camsell Range — a series of low ridges nearly 30 miles wide at 4000 feet elevation; McConnell Range — 20 miles wide at 5000 feet elevation with smooth, rounded summits; Norman Range — two ridges, relatively subdued in character rising to 2000 feet.
• Mackenzie Plain	A long, low area with rolling surface due to glacial drift deposition. Varies in width from 15 to 60 miles. General evenness of surface varied by low, parallel hills and valleys and locally by small plateaux, rounded hills and east-facing scarps. Mackenzie River and tributaries well-entrenched in steep-sided, narrow valleys 200 to 500 feet below the surface.

PHYSIOGRAPHY (cont'd)

• Mackenzie Mountains	Mountain ranges separated by broad, irregular valleys of Peel and Ogilvie Rivers. Divisible into Canyon Ranges, 400 miles long, 40 miles wide and composed of smooth profiles, plateaux and widely separated low ranges. Backbone Ranges — a series of peaks and ridges reaching 8,500 feet, have few broad valleys, no plateaux nor remnants of old land surfaces.
• Liard Plain	A large basin, mostly less than 3000 feet high. Rimmed on all sides by plateaux and mountains. Liard River well-entrenched. An area of low-wooded hills with broad timbered flats between with most of area mantled by thick glacial drift deposits sometimes more than 200 feet thick. Glacial and post-glacial stream courses and other glacial features found all across plain, more notably, the north side of the Liard River.
• Hyland Plateau	Formed of rolling hills rising to 4000 feet elevation and interspersed with broad, flat valleys. Plateau glaciated with drift deposits forming a widespread mantle and filling the main valleys.
• Selwyn Mountains	Bordering on the Yukon Plateau. Divided into 3 ranges paralleling each other and separated by broad valleys. Logan Ranges rise 8000-9000 feet; very rugged, steep ranges with broad, glaciated valleys between and large embayments of plateaux between ranges. Hess Mountains — rugged ranges rising in excess of 7000 feet and separated by big valleys and depressions scoured by glaciers. Wernecke Mountains — westernmost extension of ranges in Basin between headwaters of Stewart and Hart Rivers. Highest elevations 6000-7000 feet. Arctic Red River and Snake River occupy U-shaped, high-level valleys 3500 feet in elevation dissecting the range.
• Ogilvie Mountains	Lies between Tintina Trench and Taiga Ranges. Two belts: one 35 miles wide in the southwest, 5000 feet in elevation and the other 160 miles long, 60 miles wide rising to 7000 feet elevation. Together comprise a series of long, branching ridges connecting peaks and flanked by deep valleys.
• Tintina Valley	Comparable to the Rocky Mountain Trench; a very straight, narrow valley flanked by high ranges. 3 miles to 14 miles in width.
• Omineca and Cassiar Mountains	Essentially a continuous belt stretching along west side of Trench and Liard Plain. Basically a granitic batholith with little or no modification from stream valleys. Highest peaks may reach 8000 feet elevation.

CLIMATE

- Both tundra and sub-arctic climate regimes.
- Tundra climate — northeastern part of the Basin (to 60°N) and higher altitudes of Western Cordillera.
- Subarctic climate — remainder of Basin (below 60°N).
- Basin weather not apt to be changeable on day to day basis.
- Rapid fluctuations of temperature and humidity not common.
- Exhibits uniform weather patterns for extended periods of time.
- Dominated by polar air masses.
- In winter, low angle of solar insolation results in net loss of heat to air and consistently cold temperatures.
- Cyclonic activity usually confined to spring and fall.

CLIMATE (cont'd)

- Snowfall varies from 50" in Northeastern B.C. to 25" near Arctic coast.
- 40 to 45 per cent of precipitation falls in period June — August.

Climatic Data for a representative number of Basin stations

Station	Lat.	Mean Daily Temp. Max.	Mean Daily Temp. Min.	Mean Annual Precip.	Lowest Recorded Temp.	Highest Recorded Temp.
Aklavik (N.W.T.)	68°N	24°F	8°F	9.2"	−62°F	93°F
Fort Good Hope (N.W.T.)	66°N	28°F	6°F	9.9"	−79°F	95°F
Fort Resolution (N.W.T.)	61°N	31°F	15°F	11.1"	−63°F	90°F
Fort Simpson (N.W.T.)	61°N	34°F	14°F	13.0"	−69°F	95°F
Fort Smith (N.W.T.)	60°N	36°F	15°F	12.1"	−71°F	103°F
Beaver Lodge (Alta.)	55°N	46°F	25°F	16.8"	−54°F	95°F
For comparison: Calgary, Alta.						
Calgary	51°N	51°F	26°F	16.4"	−49°F	57°F

PERMAFROST

- One-half Canada underlain by permafrost.
- Permafrost divided into two zones: Continuous and discontinuous.

ZONE	THICKNESS	DEPTH OF ACTIVE LAYER
Continuous	200-1000 feet	1.5 - 3 feet
Discontinuous	1-200 feet	2 - 100 feet

- Also influenced by relief, drainage, vegetation, snow cover, soil type, rock type.

PERMAFROST (cont'd)

Permafrost data for selected Basin sites

Site	Thickness	Ground Temp.	Mean Annual Air Temperature
Fort Simpson (N.W.T.)	40 ft.	35-34°F	25.0°F
Fort Smith (N.W.T.)	?	about 32°F	26.2°F
Fort Vermilion (Alta.)	nil	39.8°F	28.2°F
Inuvik (N.W.T.)	>300 ft.	26.0°F	15.6°F
Mackenzie Delta	300 ft.	23.8°F	15.6°F
Norman Wells	150-200 ft.	26.0°F	20.8°F

VEGETATION

Type	Species	Areal Characteristics
Boreal forest. Other species by area.	White and black spruce dominant species. East: Jack pine and tamarack. West: alpine fir and lodgepole pine. South: white birch and balsam poplar.	Hay River: Black spruce with jack pine in the east and with lodgepole pine in the west. Upper Mackenzie white spruce and balsam on alluvial flat; white birch on levees, terraces; ridges – pines, aspen, tamarack. Floodplains of Liard and Peace and Slave Rivers – white spruce, jack pine, poplar, birch. Spruce on uplands: lodgepole pine on the Liard floodplain. Upper Liard: alluvial flats – white spruce and poplar pure stands; above floodplain spruce, pine, aspen, and fir. Plateaux – lodgepole pine, white spruce, aspen. Lower Mackenzie: Great Bear Lake to Delta – true boreal forest found only along alluvial flats and river banks. Sites with well-drained land and low permafrost table – white spruce. Uplands – white birch.
Subarctic forest – Tundra Transition Zone.	Black and white spruce. Taiga vegetation: shrubs stunted trees, heath, peat, muskeg.	Eastern Great Slave Lake, Great Bear Lake and along eastern edge of Mackenzie Mountains. Thin soils, unfavourable climate. Black and white spruce only on deep, sheltered, frost-free soils. Usually stunted stands alternate with shrub vegetation or rocky barrens.
Alpine	Great diversity of species; white spruce, Engelmann spruce, alpine fir, Douglas fir and lodgepole pine.	Northern and eastern exposures support Engelmann spruce, white spruce, alpine fir. Southern and western exposures – Douglas fir and lodgepole pine. Tree line at roughly 7000 foot elevation.
Alpine Tundra	Several plant species; snow willow and others: drought resistant, wind resistant and low lying.	Ranges from 7500-foot elevation to rocky peaks of the mountains. No trees found in this region because of climatic conditions.

VEGETATION (cont'd)

Type	Species	Areal Characteristics
Aspen Parkland	Dense stands of aspen poplar, willow and prairie grasses.	Found in the Peace-Athabasca Delta, Peace River Lowlands and several small areas in Northeastern Alberta. Groves of aspen poplar interspersed with prairie grasses. Stream valleys support dense stands of aspen and willow.
Tundra	Treeless, limited to plant species; lichens, mosses, grasses, cushion plants and shrubs, i.e. — wild crocus, mountain avens, arctic poppy.	Three divisions: sedge-grass tundra, heath tundra, and moss-lichen tundra. Sedge-grass tundra - Mackenzie Delta; shrub-heath tundra — southern portion nearest to the subarctic forest zone. Dwarf birches, creeping willows interspersed with heather and moss.

SOILS

Group	Drainage	Parent Material	Fertility	Horizons
• Grey Wooded	Well and imperfectly drained	Neutral to alkaline in reaction. Vegetation — coniferous-Deciduous or Boreal Forest.	Low	Impoverished, light grey, leached layer at or near surface. Organic layer — thin, leafy mat.
• Sub-groups • Dark Grey Wooded • Dark Grey • Orthic Grey Wooded				Dark grey surface horizon 3 to 10 inches. Light, grey platy structured sub-surface.
• Grey-Brown Podzolic	Well and imperfectly drained	Coniferous and mixed forests.	Medium	Pronounced horizons, extensive leaching and good moisture content. Grey layer at or near the surface. Organic matter accumulated in sub-surface horizon.
• Brunisolics (Brown)	Good to imperfect drainage	Forest, mixed forest, heath, tundra and alpine. Neutral to mildly alka-line reaction.	Medium	No grey leached, horizon or enriched subsurface horizon. Well-developed horizons.
• Sub-group • Acid Brown Wooded		Mild to moderately alkaline reaction. Forest-alpine transition zone.		
• Gleisolics	Water saturated	Mixed forest, peat, heath, moss, tundra.	Low	Organic surface of less than 16 inches of peat and up to 24 inches of peat moss. Restricted horizon development due to excessive water and little aeration.
• Sub-group • Humic Glusols				Dark coloured — more humus in subsurface.
• Eluviated Gleisols				Podzolization present.
• Tundra (Organic)	Very poorly drained	Bare rock, tundra. Strongly acid in reaction.	Low	Underlain by permafrost and organic horizon fairly thick. No horizons, northern counterpart of Gleisolics.

SOILS (cont'd)

Group	Drainage	Parent Material	Fertility	Horizons
• Subarctic	Free drainage, varying types of drainage form varying grades of soils.	Thin, shallow soils. Found on terraces and dune sands.	Low	Podzolization and other processes weakened due to severe climate. Brown in colour from mineral elements combining with organic residues. Little leaching, no transfer of mineral elements.
• Sub-group • Subarctic Brown Forest				Mineral in character and formed when subarctic forest present.
• Regosolics	Well to imperfectly drained	Sand dunes loess, recent glacial till. Good to moderate oxidizing conditions.	Low	Thin and grey in colour; only surface horizon may be developed. Sub-surface deep, unconsolidated, soft mineral matter.
• Lithosols	Little or no drainage	Slopes with excessive, often erosive runoff and glacial till.	Low	No leaching or weathering; little plant humus, surface horizon grey.
• Alluvials	Good drainage	Parent material sediments from river.	Good	Varied profile and depth according to the depth of active deposition.
• Mountain Soils	Great differentiation	Parent material derived by *in situ* weathering and mass movement alluvial, glacial and periglacial action.		Shallow, high stone and gravel content. May exhibit characteristics of other predominant groups according to site, exposure and denudation.

FACT SHEET NO. 3: GEOGRAPHY OF THE BASIN

the Grey Wooded Soils and Podzols. Due to the severe climate of the region, podzolization and other similar processes tend to be weakened. This process weakens but does not grade into a special type of soil formation. The mineral elements tend to combine with organic residues to produce a brown colour in the upper horizon. Leaching is very feeble and no visual translocation of mineral elements is noted in the profile. Subarctic soils or Arctic Brown and Subarctic Brown Forest Soils are the soils of the arctic region. They are mineral in character and form under free drainage. Their areal extent is small and is confined primarily to escarpment areas, terrace edges and stabilized dunes.

Regosolic, Lithosolic and Alluvial Soils may be classified as part of the Subarctic division except they also occur in other climatic regions.

Regosolic soils are well drained to imperfectly drained soils with good to moderate oxidizing conditions. They have unconsolidated deep, soft mineral matter in which only the surface horizon may be developed. Regosolic soils are usually thin and grey in colour and are confined to sand dunes, loess and recent glacial till.

Lithosols usually occur on slopes with excessive, often erosive runoff and little water entering the soil to promote leaching and weathering. Lithosols, composed of coarse sand and gravel, contain little plant humus, and have a grey surface horizon. Their depth depends upon how much recent erosion has taken place and the erosibility of the parent material. Soil development on till is slower due to freshness of materials, higher content of unweathered rock and compaction of ice.

Alluvial soils are classified by texture and by textural profile and may vary greatly in depth according to the degree of active deposition. They include sandy alluvium, moist strips close to levees, areas near side slopes of rivers, and areas upon valley sides.

The last soil group to be discussed is Mountain Soils. In general they exhibit Lithosolic or Regosolic characteristics and their parent material is derived by in situ weathering or by mass movement. Other parent materials may be alluvial in nature, glacial or periglacial in origin. The soils are shallow, have a high stone and gravel content due to their slight biological activity, sparse plant debris and slow biotic action. Mountain soils differ primarily because of variations of site, and exposure.

4. HYDROLOGY

4.1 Factors Affecting Runoff

In the Mackenzie Basin there are three broad hydrologic zones corresponding to the three geologic areas of the Western Cordillera, the Interior Plain and the Canadian Shield. However, runoff is a complex phenomenon resulting from a number of interrelated climatic and physiographic factors. The most important of these factors that affect runoff in the Mackenzie Basin are:

(a) Precipitation

Runoff variability is influenced by the type of precipitation, its seasonal distribution and intensity. The Cordillera and Interior Plains both exhibit pronounced maximum and minimum periods whereas the Shield has a more even distribution. All three areas are subject to intense, short rainstorms due to cyclonic activity, which may produce maximum monthly runoff later in the year. The Cordillera has a higher runoff due to orographic rainfall.

(b) Temperature

Temperatures below 32°F for six months of the year result in low runoff during the winter. In spring, temperatures begin to rise in the south and west and the rise progresses north-eastward, producing a concurrent snowmelt progression. A sudden and prolonged rise in temperature during this period can create severe flooding.

(c) Evaporation

Most of the evaporation occurs between mid-April and mid-October when mean air temperatures are above 32°F. Evaporation is negligible during the winter because of low temperatures, frozen surfaces, and a minimum of solar radiation. The amount of evaporation varies with the proportion of lake and pond area in the drainage basin, degree of imperviousness of surface, ruggedness of terrain, and channel density.

(d) Vegetation

Regional vegetation has a significant effect on annual runoff. It is estimated that the annual water loss by evapotranspiration in the forested area is 2.5 inches per year greater than the water loss from the barren lands. Transpiration losses again depend upon the amount of water available and the water retaining characteristics of the land surface.

(e) Topography

The mountainous areas of the Cordillera receive relatively high precipitation due to orographic effects. The steeper slopes and more impermeable terrain also contribute to a higher rate of runoff than the plains to the east. In addition, some of the higher mountain peaks have small permanent glaciers which contribute to streamflow during the summer months. The Interior Plain has a very flat-lying terrain, a higher degree of water porosity (where continuous permafrost is not present), little orographic rainfall, and a low channel density. In the Shield there are no orographic effects on precipitation, the gentler slopes do not generate a rapid rate of runoff, and the vast number of lakes and ponds tend to reduce the variability of streamflow.

(f) Groundwater

Groundwater provides an important source of water for streamflow, particularly during the winter season. Movement of groundwater is otherwise restricted by the presence of discontinuous or continuous permafrost which restricts (1) infiltration; (2) surface storage to depressions and to the active layer and; (3) the movement of groundwater between local drainage basins and larger basins. Due to the relatively impervious nature of the Precambrian Shield, groundwater contribution to the rivers in this area is small. Except in those areas of the Interior Plain underlain by permafrost, there is an appreciable inflow of groundwater, owing to a mantle of glacial drift which overlies the entire area. In the Cordillera, groundwater movement occurs mainly along joints, fractures and fault zones as evidenced at many bedrock springs.

(g) Lake Storage

Withdrawal from lake storage is the main source of streamflow during the winter months when precipitation is being stored on the ground surface in the form of snow. Lake storage is augmented by groundwater discharge. Many of the lakes also contribute directly to groundwater recharge or behave as groundwater discharge areas. Therefore, the number and capacity of the lakes in a drainage basin as well as their role in the groundwater system have a considerable effect on the temporal distribution of runoff.

4.2 Regional Hydrology

The three broad hydrologic zones of the Mackenzie Basin correspond generally to the three geologic zones: Western Cordillera, Interior Plains, Canadian Shield. The hydrologic regimes vary widely not only between these zones but also within them.

The vastness of the Basin allows distinct regional differences in the various factors affecting runoff. Peak discharge particularly in the larger basins, results from snowmelt. Spring break-up occurs during May in the southern portion of the Basin, during April in the Cordillera and in early June in the Shield area. In the smaller basins peak flows may result from cyclonic storms during the summer months. A notable example is the storm which

RUNOFF CHARACTERISTICS

- Factors affecting the general hydrologic regime and runoff patterns are as follows: precipitation, temperature, permafrost, groundwater, topography, vegetation, lake storage, and soil and rock type.
- Total drainage area of the Mackenzie River Basin: 696,700 square miles, mean discharge of the Mackenzie River: 380,000 cfs. or .54 cfs/square mile.

Area	Runoff	Contributing Factors	Coefficient of Variation of Annual Flow
• Western Cordillera	20" (headwaters of Peace and Athabasca) 15" (headwaters of S. Nahanni and Liard)	Steep slopes; High channel density.	.25 – .40
• Interior Plain	1" – 5"	Flat terrain, long graded slopes; high permeability of glacial drift in permafrost-free areas; less lake storage, high evaporation rate.	.15 – .20
• Shield	2.5" – 5.5"	High proportion of lake area; even distribution of flows throughout year.	.20 – .30

- June is peak month, although delayed storage levels may hold natural flow until July.
- Cyclonic activity may produce peak flows in small streams as late as August.
- At least 50% of mean annual flow may occur during the five-month period of May to September.

MEAN ANNUAL FLOWS – 6 STATIONS

Station	M.A.F.* (cfs.)	Distribution of Mean Annual Flow Jan.-Apr.	May-Aug.	Sept.-Dec.
Athabasca River below Fort McMurray	22,700	13	63	24
Peace River at Peace Point	81,100	8	73	19
South Nahanni River above Virginia Falls	8,620	4	77	19
Camsell River at outlet of Clut Lake	3,390	29	31	40
Liard River at Fort Liard	78,100	7	73	20
Mackenzie River at Norman Wells	326,000	21	45	34

*Mean Annual Flow

occurred in July 1970 in the Arctic Red River Basin and produced a peak runoff of 278,000 cfs over a 5,000 square mile watershed.

Mean annual runoff increases from about 4 inches in the Interior Plains and Canadian Shield to about 13 inches in the Western Cordillera. The mean annual runoff is about 25% of mean annual precipitation in the Canadian Shield, and about 75% of mean annual precipitation in the Cordillera. While stream gauging stations are numerous and have reasonable lengths of record in some southern portions of the Basin (particularly along the Athabasca River), there is a paucity of streamflow data in the central and northern areas (Fig. 8).

The Western Cordillera

The major river systems in the Western Cordillera are the Peel, the Liard and the upstream portion of the Peace (Fig. 8). In these basins the precipitation regime is characterized by minimum amounts during March and April, and maximum amounts during June and August. An even distribution of precipitation marks the remaining months. Average annual precipitation varies from 7 inches in the north to 25 to 30 inches in the upper reaches of the South Nahanni River of the Liard Basin.

Rapid spring runoff is typical of mountain streams. Spring break-up occurs in late April and peak flows develop in the snowmelt period between mid-May and early July. About 50% of the runoff occurs during this period, and 90% in the five-month period from May to September. On the main streams, peak flows are the result of snowmelt and may start within two weeks of break-up, whereas the peak flow for the smaller streams may result from heavy summer rains. There is little natural storage because of high relief and the presence of impermeable permafrost. The mean annual runoff in this area varies from 4 inches in the north to 12 to 18 inches in the south. During winter the streamflow is largely dependent upon groundwater with the lowest flows usually occurring in March. In winter, minimum monthly flows for streams rising in the mountains average between 0.10 and 0.20 cfs per square mile.

The Interior Plain

The Interior Plain encompasses the main stem of the Mackenzie River, the lower reaches of the Liard, Peace and Athabasca River Basins, and the three major lakes (Fig. 8).

The mean annual precipitation in the Interior Plain averages from 7 inches in the northeast to 20 inches in the extreme south. The average across this area is 16 inches per year. Fort Smith, for example, receives 14 inches per year. Approximately 50% of the annual precipitation falls in the form of snow from October to April while the other 50% falls as rain from May to September. Some of the region is underlain by both continuous and discontinuous permafrost, which results in little infiltration and correspondingly, groundwater movement is small (see Section 3.4 Soils).

The Canadian Shield

The Canadian Shield exhibits many of the same general hydrologic characteristics as those of the Interior Plain. Average annual precipitation is approximately 7 inches and may vary slightly according to locale; for example, the east shore of Great Slave Lake may experience an annual precipitation of up to 10 inches. In the Shield, flows tend to be more evenly distributed throughout the year because of the high proportion of lake area. Spring runoff commences in late May or early June and is usually completed within a month. Heavy summer rains alone or in combination with June meltwaters produce peak flows between mid-July and early October. After the October freeze-up, there is little or no runoff, so that streamflow is maintained by withdrawals from lake storage.

In the Shield, the lowest flow during the year is usually about 25% of the mean annual flow, the actual percentage depending on the amount of lake storage in the watershed. In the Interior Plain the lowest flow may be only 5% to 10% of the mean annual flow due to the lack of lake storage. The mean annual runoff in the Shield varies from 2.5 to 5.5 inches.

4.3 Observations

It must be pointed out that the data on the hydrology of the Mackenzie River Basin are by no means complete. Studies have been done on the Liard River Basin as far south as 60°N latitude, the Lockhart River, the area immediately south of Great Slave Lake as far as 60°N latitude, and the Peace-Athabasca system. In the rest of the Mackenzie Basin, data have been gathered from a very few gauging stations and extrapolated along with data taken from the existing meteorological stations. For instance, the hydrologic regime of the Interior Plain has been interpreted in terms of its homogeneous physiographic characteristics.

5. THE NATURAL RESOURCE BASE

5.1 Renewable Resources

The fisheries resource base in Lake Athabasca and Great Slave Lake includes walleye, goldeye, northern pike, burbot, lake trout, whitefish and inconnu. This diverse base contributed to a total catch in 1969 of 1,139,000 pounds in Lake Athabasca and approximately 6 million pounds in Great Slave Lake.

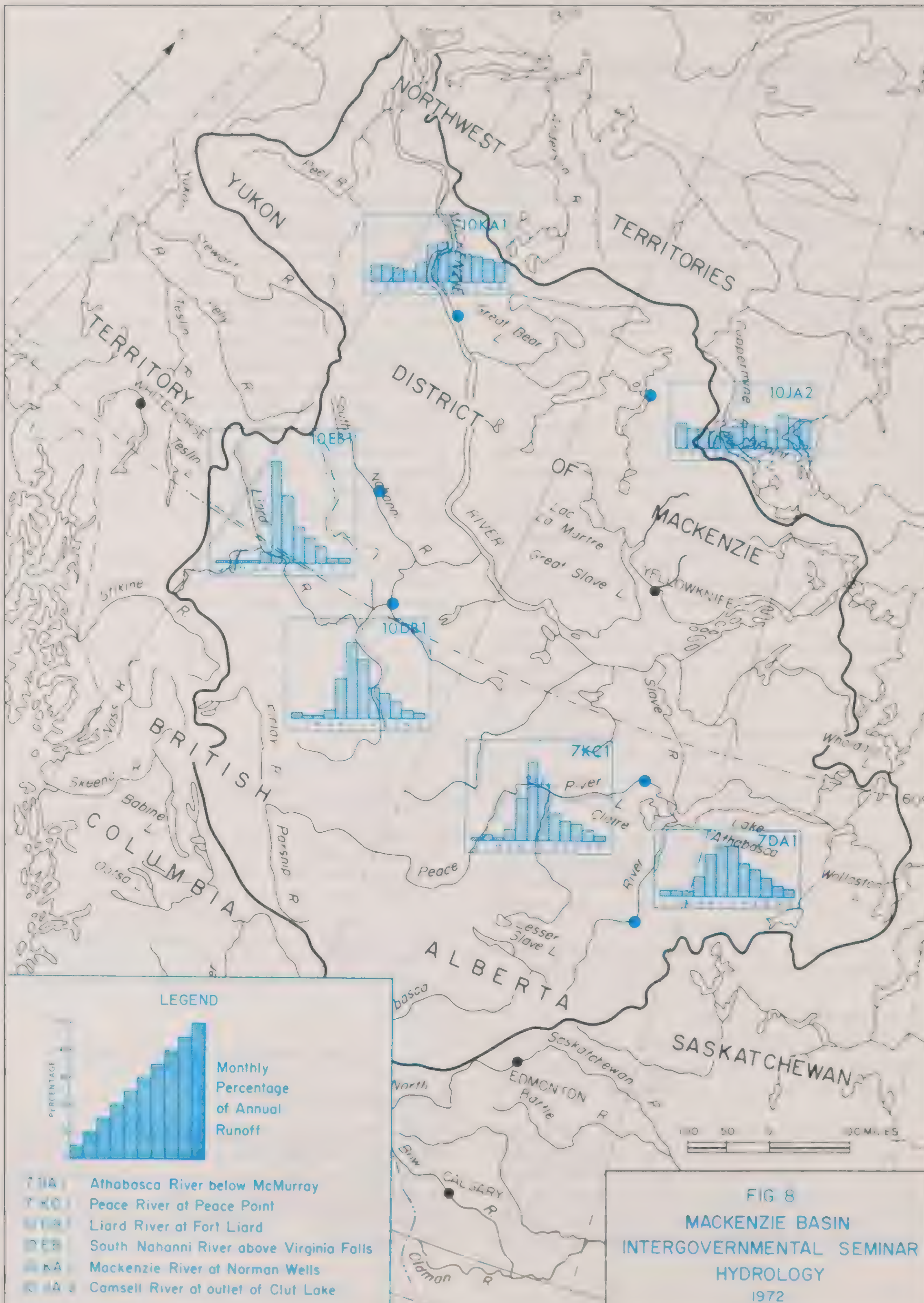


FIG 8
MACKENZIE BASIN
INTERGOVERNMENTAL SEMINAR
HYDROLOGY
1972

RENEWABLE RESOURCES

Fish

Annual commercial catch of important species (in pounds) for the two major commercially fished lakes

Species	Great Slave Lake (1967)	Lake Athabasca (1969)
northern pike	412,276	185,900
walleye (pickerel)	35,067	129,600
whitefish	2,281,073	651,800
lake trout	658,497	171,900
inconnu	234,439	–
burbot	21,286	–

- Great Slave Lake accounts for 97% of commercial catch of Mackenzie District (1967).
- Above species are caught as sport fish, as are arctic char, grayling, herring in Great Bear Lake, and arctic "cisco" in Arctic Red River area.
- Most important commercial species are whitefish and lake trout (account for 95% of production in 1967).
- Domestic fisheries also operate in the basin, and fish are sold locally through cooperative stores, as at Fort Franklin.

Wildlife

- Size of the Basin and the uniqueness of the Mackenzie and Peace-Athabasca Deltas contribute to a large and varied wildlife population.

Size of the Basin and the uniqueness of the Mackenzie and Peace-Athabasca Deltas contribute to a large and varied wildlife population.

Wildlife	Peace-Athabasca Delta	Mackenzie Delta
Birds	Staging point of North America's flyways.	Nesting grounds for many species of geese, ducks, swans, ptarmigan, etc.
Furbearers	Muskrat, beaver, mink, otter, lynx.	Muskrat, beaver, mink, otter, etc.
Mammals	Buffalo maintained in Wood Buffalo National Park.	Reindeer preserved in Mackenzie Reindeer Grazing Reserve.

- Barren-ground caribou migrate across the Mackenzie Delta to their summer breeding grounds on tundra.
- Endangered species such as trumpeter swan, peregrine falcon, and whooping crane preserved in these deltas and various bird sanctuaries.

Agriculture

- 1,092,800 acres of arable land situated along the floodplains of the Mackenzie, Slave, and Liard Rivers.
- Since these areas of the Territories are forested, evaluation of conflicting resource uses must be carried out.
- Agriculture dominates Peace River District's economy despite recent resource development.

RENEWABLE RESOURCES (cont'd)

Forest

- 14 billion cubic feet of merchantable timber in NWT portion of basin.
- Common species: white spruce (most valuable), black spruce, balsam poplar, jackpine (most abundant), white birch, and aspen, found on fertile floodplains of the rivers of the basin.
- White spruce commercially exploited in these areas.

Location	Species	Reserves (b.f.)
Lower Slave River	White Spruce	85,000,000
Mackenzie River	White Spruce	206,000,000
Lower Liard River	White Spruce	2,757,000,000
	Poplar	2,427,000,000

- Eight major forest areas in Alberta portion of the basin shown with potential annual yields (1968):

Area	Sawlogs (Mill, B.F.)	Pulpwood (M. Cords)
Edson Forest	112	1528
Whitecourt Forest	101	1755
Grande Prairie Forest	90	1498
Peace River Forest	73	1451
Slave Lake Forest	138	2675
Footner Lake Forest	101	1714
Lac La Biche Forest	57	1156
Athabasca Forest	62	1040

Power

- Supplied by hydro-electric plants and local oil-fired thermal plants.
- Northern Canada Power Commission (NCPC) operates 3 hydro electric-plants.

Station	Location	Capacity
Twin Gorge (NCPC)	Taltson River	18,000 KW
Snare Rapids (NCPC)	Snare River	7,000 KW
Snare Falls (NCPC)	Snare River	7,000 KW
Bluefish Lake (Cominco)	Yellowknife River	4,000 KW

- Most communities have small diesel electric plants, average size of 500 to 1000 kilowatts (KW).

RENEWABLE RESOURCES (cont'd)

- Several potential sites for hydro development in northern part of basin.
- In the Athabasca Basin, hydro sites are limited to small plants due to river bank structure, variability of river flows and low precipitation.

NON-RENEWABLE RESOURCES

Minerals

- Estimated Reserves:
- Iron ore in billions of tons.
- Base metals at 100 million tons.
- Asbestos in millions of tons.
- Production (1970) in NWT part $124 million.
- Mines and Minerals.

Type	Location	1970 Production	Value
Gold	Yellowknife	328,502 ozs.	$12,381,240
Silver	Great Bear Lake	2,525,000 ozs	$ 4,671,250
Copper	Great Bear Lake	1,086,800 lbs.	$ 631,100
Lead	Pine Point	220,000,000 lbs.	$34,804,000
Zinc	Pine Point	450,000,000 lbs.	$71,685,000
Uranium	Uranium City	2,001,648 lbs.	$12,249,510

Producing Mines in the Mackenzie Basin

Name of Mine	Product	Rate (tons/day)	Grade (ozs./ton)	Reserves (tons)	Employees
Giant Yellowknife	gold	1,160	0.69	1,444,500	.420
Supercrest	gold	150	0.69	129,000	operated by Giant
Lolor	gold	100	0.66	340,000	operated by Giant
Con.-Rycon-Vol.	gold	525	0.67	N.A.	238
Pine Point	lead zinc	10,500	0.9%	41,800,000	520
Terra Mining	silver bismuth copper	150	N.A.	N.A.	61
Echo Bay	silver copper	100	65	N.A.	102
Canada Tungsten	tungsten copper	450	1.61% 0.45%	733,823	66
Eldorado	uranium	2,000	N.A.	N.A.	N.A.

Oil and Gas

- In Northwest Territories, 450,000 square miles underlain by sedimentary rocks ranging in age from Cambrian to Tertiary considered oil and gas deposits.
- Norman wells – only oil-producing well north of 60°, 1970 daily production of 2,614 barrels ano reserves of 12 to 48 million barrels recoverable.

RENEWABLE RESOURCES (cont'd)

- Imperial Oil discovered oil at Atkinson Point in January 1970, but further testing needed to estimate reserves.
- Gas has been discovered in 9 separate areas of the Northwest Territories.
- Pointed Mountain, only gasfield currently under development, will go into production in November 1972, with reserves (proved and probable) of 1.006 to 1.403 trillion cubic feet.
- Beaver River gasfield on Yukon-British Columbia border in an area to the south and adjacent to Pointed Mountain field started production in November 1971 with completion of Fort Nelson pipeline now being extended to Pointed Mountain field.
- Reserves of Athabasca Tar Sands estimated at 300 billion barrels oil and 300 trillion cubic feet of gas (recoverable).

Oil and Gas Fields

Major Area	1971 Oil Production	1971 Gas Production
Norman Wells, N.W.T.	944,083 barrels	892,630 mcf (1970)
Swan Hills, Alta.	32,973,000 barrels	17,659,000 mcf
Rainbow Lake, Alta.	24,297,000 barrels	19,336,000 mcf
Kabob South, Alta	2,499,000 barrels	107,016,000 mcf
Edson, Alta.	137,000 barrels	104,855,000 mcf
Windfall, Alta.	280,642 barrels	61,749,000 mcf
Northeastern British Columbia	25,268,000 barrels	180,866,000 mcf

- Much exploration activity due to Pan Arctic and Esso discoveries.
- Expansion of Great Canadian Oil Sands Ltd. facilities at Fort McMurray and Syncrude Ltd.
- Development will greatly affect the future of southern part of the Basin.

FACT SHEET NO. 5: NATURAL RESOURCE BASE

The aforementioned species in addition to arctic char, grayling and herring are also caught as sport fish throughout the Basin with Great Bear Lake being a major sport fishing site.

Wildlife in the Basin also exhibits the same diverse characteristics as the fish resource. The number of species and size of the Basin area all contribute to the large size of the wildlife population. The ecological importance of the Basin as a breeding ground and staging area for many bird species (geese, ducks, etc.) and as a home for fur-bearing animals (muskrat, beaver, mink, otter, etc.) has given added weight to the preservation and maintenance of the two main deltas of the Basin, the Mackenzie and Peace-Athabasca. The two deltas are also supported by the creation of Wood Buffalo National Park for buffalo, the Mackenzie Reindeer Grazing Preserve for reindeer, and various bird sanctuaries for endangered species such as the bald eagle, trumpeter swan and whooping crane. Barren ground caribou migrate across the Mackenzie Delta to their breeding grounds north of Great Bear Lake.

Estimates indicate that there are 14 billion cubic feet of merchantable timber in the Northwest Territories. Most species such as white spruce and jack pine are found on the alluvial flats of the Mackenzie River floodplains where higher summer temperatures, longer growing season, better aerated and deeper soils contribute to tree development.

The most valuable tree species is the white spruce averaging between 20,000 and 25,000 board feet per acre. Balsam poplar and jack pine are second and third respectively in commercial value. Alberta's forests contribute $135 million annually to the economy, with white spruce the most valuable species. Only about 1/5 of Alberta's annual forest capacity is being used at present and the

province's ultimate potential is ten times its current production. Lodgepole pine, trembling aspen and balsam poplar are also important contributors to the forest resources of the Basin.

There are approximately 3.5 to 4.0 million acres of arable land in the Territories and most is located along the river floodplains of the Mackenzie Basin. Major blocks of arable land have been classified along the Slave, Liard and Peace Rivers. The Canada Department of Agriculture operates an experimental station at Fort Simpson on the Mackenzie River. The parameters for indicating the arability of the land are the same as those of the forest resources, i.e. soils, climate and topography.

Power is supplied by the Northern Canada Power Commission's hydro-electric plants and local oil-fired thermal plants. Most communities are served by small thermal plants while the community of Pine Point is supplied by the Twin Gorge hydro plant on Taltson River which has a capacity of 18,000 kilowatts (Fig. 9).

5.2 Non-Renewable Resources

Three major areas of non-renewable resources activity in the Territories include: 1) the Mackenzie district with five gold mines at Yellowknife, a silver-copper mine at Great Bear Lake, a lead-zinc mine at Pine Point and a silver mine at Rainy Lake; 2) the Nahanni district with a tungsten-copper mine north of Watson Lake, and (3) the Peace-Athabasca region with a uranium mine at Uranium City. Production in 1970 in the Territories was $124 million exclusive of oil and gas (Fig. 10).

In the Basin it has been estimated that 15 billion barrels of oil and 90 trillion cubic feet of gas constitute the potential reserves of crudes recoverable by conventional methods. Norman Wells, at present, is the only producing oil field north of 60° Latitude and 1970 production reached 2,614 barrels per day. Beaver River and Pointed Mountain are the only producing gas fields and are scheduled to go into production in late 1971 and 1972 respectively.

The Athabasca Tar Sands at Fort MacMurray in Alberta is probably Canada's largest single oil field. Recoverable resources are estimated at approximately 300 billion barrels of oil with an additional 300 trillion cubic feet of gas recoverable through processing.

Exploration continues in the Basin with the Mackenzie Delta and surrounding area being the major concentration of exploratory activity. Oil was discovered at Atkinson Point in early 1970 but further testing is needed for estimating recoverable reserves and the economic feasibility of utilizing these reserves. In 1972 there will be fifteen drilling rigs in operation in the Basin.

6. THE PEOPLE OF THE BASIN

6.1 Historical Significance

6.1.1 Indigenous People

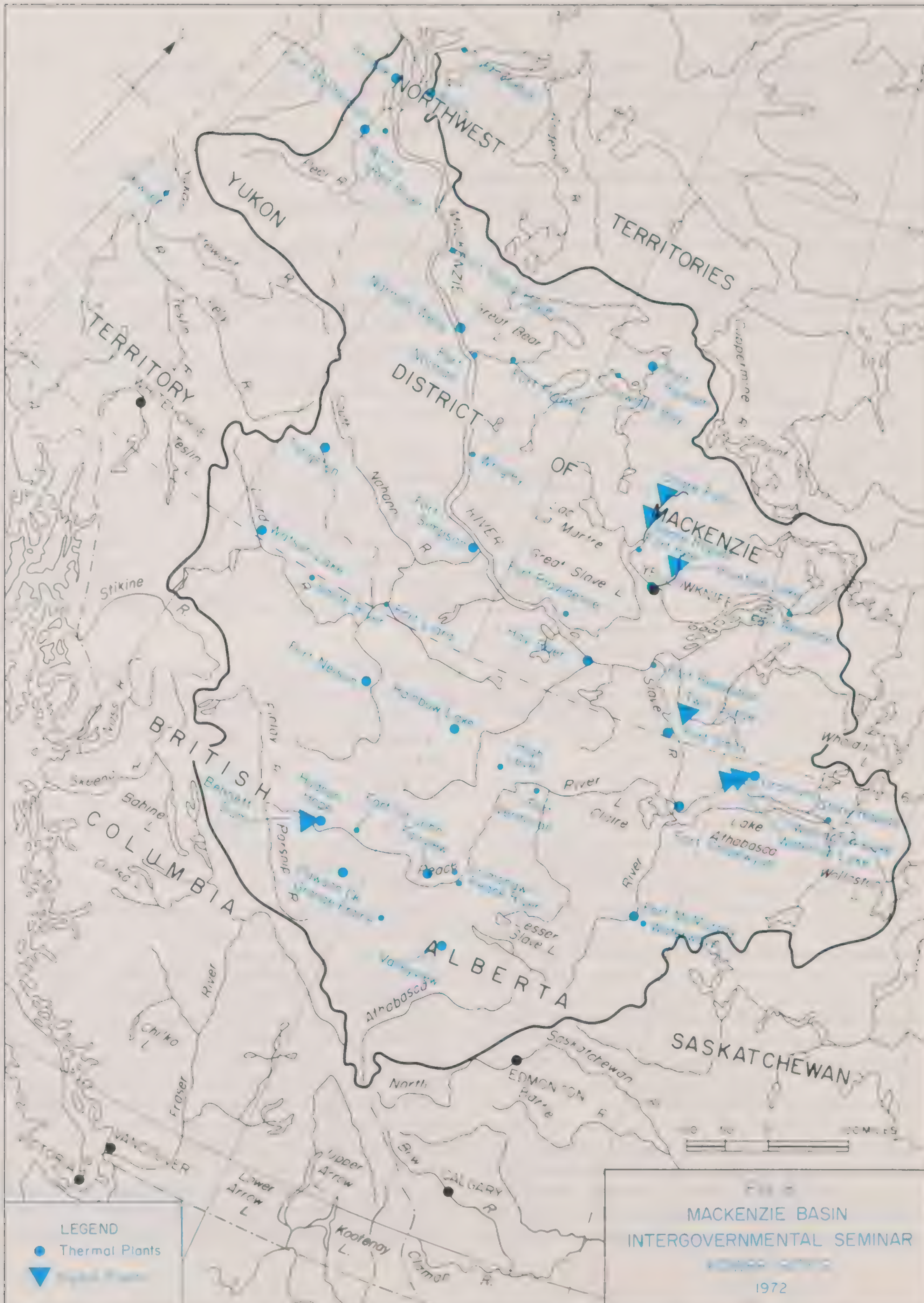
Traditionally, the Indians and Eskimos of the Mackenzie Basin have practiced a nomadic hunting and gathering way of life. Utilizing the natural fish and wildlife resources of their environment, the various tribes and bands provided for themselves clothing, fuel, weapons, and food. Archaeological evidence indicates that this culture is at least 5,000 years old.

Several Indian tribes have been identified in the Mackenzie River Basin, including the Chipewyan, Yellowknife, Dogrib, Hare, Bear Lake and Athapascan Loucheux. The Eskimos gathered in small family groups in the Arctic coastal and tundra areas, and ventured inland only to hunt caribou and muskoxen in summer. Although their lifestyles were similar, there was little cultural exchange or intermarriage between the Indian and Eskimo groups.

The first contacts with the white man came during the 16th to 18th centuries. European explorers such as Samuel Hearne and Alexander Mackenzie were hired by the Hudson's Bay Company and the Northwest Company to seek out the fur riches of the Northwest. In the late 1800's, the focus of this fur trade shifted to the Mackenzie Valley. The establishment of permanent trading posts, coupled with the expansion of Anglican and Catholic missionary activity, meant the growth of new settlements along the major waterways.

As a result of this activity, the Indians and Eskimos of the Mackenzie Basin began settling near the trading posts and missions. The extension of the Northwest Mounted Police to these settlements in the late 1800's brought the white man's law and value system, which was superimposed over the old tribal codes. Treaties were signed guaranteeing the Indians, Eskimos and Metis exclusive rights to hunting and trapping in certain areas. The game preserve areas include the Yellowknife, Slave and Peel River preserves. In 1938, the Mackenzie Mountain Preserve and Wood Buffalo National Park were created with trapping privileges extended to indigenous people only.

The loss of their traditional way of life has been fraught with difficulties for the native peoples, many of whom lack the training to pursue the specialized jobs of the technical


NORTHWEST
TERRITORIES
YUKON
TERRITORY
DISTRICT
OF
MACKENZIE
BRITISH
COLUMBIA
ALBERTA
SASKATCHEWAN
Peel R.
MACKENZIE
RIVER
Great Bear L.
Great Slave L.
Lac La Martre
Nahanni
Stikine R.
Babine L.
Lake Athabasca
Lesser Slave L.
Athabasca
Peace
Parsnip R.
Fraser
River
Chilko L.
North Saskatchewan R.
EDMONTON
VANCOUVER
CALGARY
Bow R.
Upper Arrow L.
Lower Arrow L.
Kootenay L.
Slave R.
Claire L.
Wollaston L.
Coppermine R.
LEGEND
Thermal Plants
MACKENZIE BASIN
INTERGOVERNMENTAL SEMINAR
1972

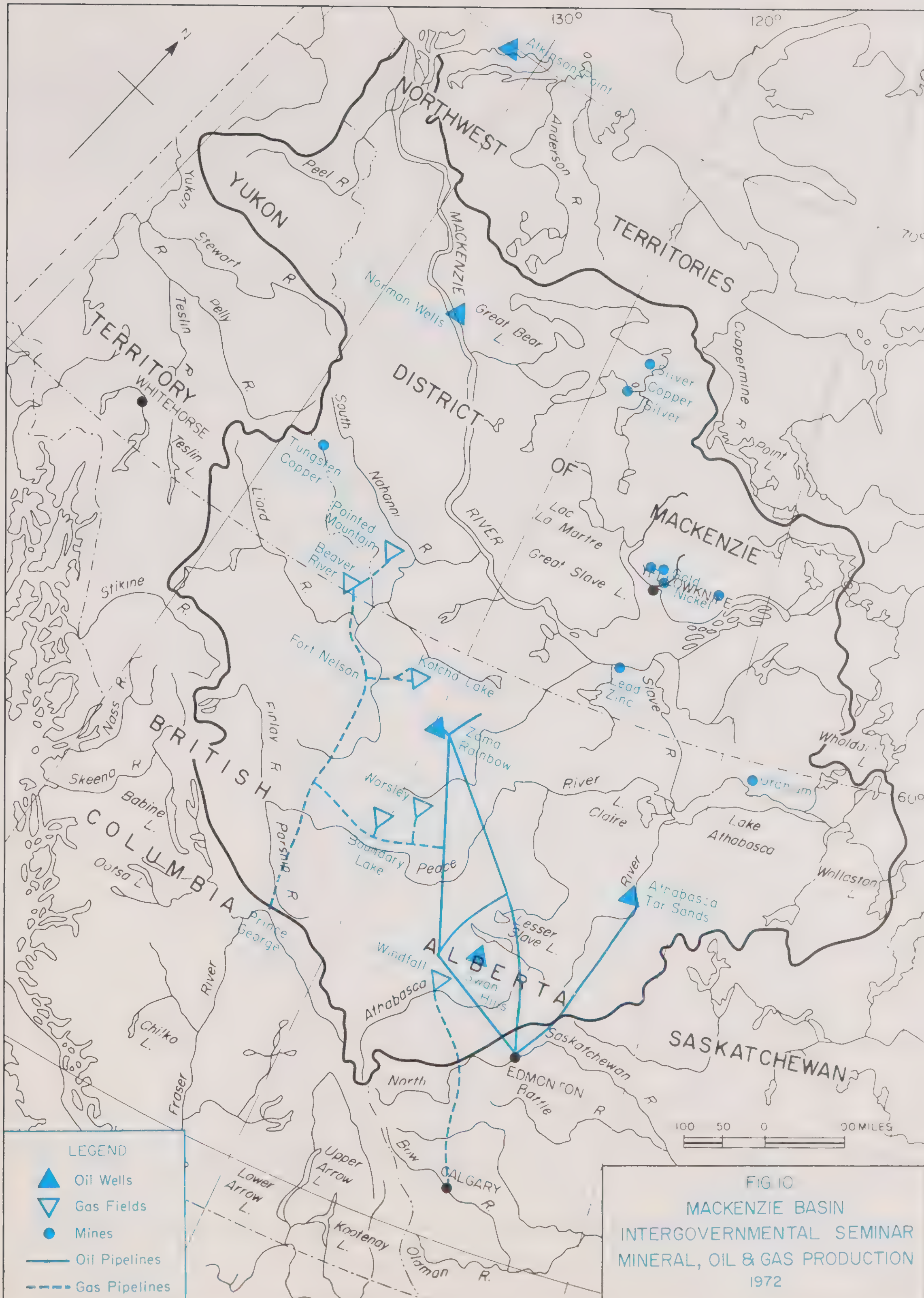


FIG 10
MACKENZIE BASIN
INTERGOVERNMENTAL SEMINAR
MINERAL, OIL & GAS PRODUCTION
1972

world. Many have become dependent upon social assistance. The establishment of training schools in the larger centres and self-teaching projects, such as Alberta's Newstart program, may help to remedy this situation.

6.1.2 Development by the White Man

The development of the Mackenzie Basin has been indissolubly linked with the development of the Mackenzie waterway. The waterway was developed in the late nineteenth century by the Hudson's Bay Company to transport furs to the southern market. The Company also created the Mackenzie River Transport Company, whose barges transported finished goods and supplies northward. Barge traffic increased dramatically with the mining discoveries at Port Radium, and the transport company enjoyed a virtual monopoly. In 1934, the Northern Transportation Company Limited (NTCL), a Crown Corporation, was formed to transport supplies for the Eldorado gold mine on Great Bear Lake, and later at Yellowknife. During and after World War II, N.T.C.L. became the dominant Mackenzie carrier. In 1957, the Mackenzie River Transport Company was sold to the N.T.C.L. Recent oil and gas exploration activity has resulted in increased use of the waterway.

Although the native population has steadily increased since 1900, it has been the influx of whites associated with various resource developments and government programs which has spurred area development. The discovery of oil at Norman Wells in the 1920's, the discoveries of minerals such as gold at Yellowknife, radium at Port Radium and pitch-blende at Great Bear Lake in the 1930's, drew many whites. The war years contributed to airfield construction and resulted in the building of the Alaska Highway. With the discovery of uranium and base metal deposits near Great Slave Lake, more people were attracted to the middle north. Also, during the 1950's the Mackenzie Highway was extended to Yellowknife. This was the beginning of a trunk road system which has been greatly expanded during the 1960's. A recently announced development plan will see much greater expansion in the next 20 years.

6.2 Present Demography

Since 1961, the total population of the Northwest Territories has increased by 43%, and the white population by 83%. The total population of the Mackenzie Basin, based on 1970 estimates is approximately 234,000. There

Table 1. Labour Force in Selected Communities in the Mackenzie Basin

Community	Resources		Labour Force						Commercial and Industrial Enterprises			
	Renewable	Non-Renewable	No.	Skilled	Unskilled	M.	F.	No.	Type and No.	No. employed	Local People	Imported Labour
Aklavik	Fish Furs	Coal	57	21	36	37	20	12	Retail (3) Commercial (2) Industrial (7)	44	40	4
Arctic Red River	Hunting		34	12	22	24	10	2	Retail (1) Commercial (1)	2		2
Fort McPherson	Fish	Oil Exploration	343	63	280	209	134	14	Retail (3) Industrial (2) Oil (8) Furs (1)	144	29	115
Tuktoyaktuk	Fish, (whale, Trout) Reindeer	oil expansion	177	10	167	127	50	15	Retail (3) Comm. (3) Municipal (2) Const. (4) Trans. (2) Oil (1)	261	143	118
Wrigley	Furs Domestic Fishing	Redstone mines (zinc, lead copper, silicon)	41	4	37	41	–	4	Retail (1) Power (1) Furs (1) Federal (1)	10	5	5
Fort Simpson	Game, Market Gardening Forest, Furs	Cadillac Mines (lead, silver) Gravel deposits	46	16	30	46	–	27	Retail (4) Transp. (3) Gov't (6) Municipal (4) Oil (10)	269	136	133

are approximately 100 communities in the Basin with populations greater than 25. Larger centres include Fort McMurray (6,750), Yellowknife (6,000), Inuvik (3,030), Fort Smith (2,500) and Uranium City (2,400). The average population density is one person per 50 square miles. This compares to the total Canadian density of over 5 persons per square mile.

The present population of the Basin is characterized by a large group in the 0 – 4 year age category and a low percentage in the over 60 age group. This is due primarily to a high birth rate among the native population, and a shorter average life span, particularly for Eskimos, coupled with a strong tendency for whites to leave the region at retirement age. The disproportionately high male to female ratio (approximately 126:100) in the region is largely affected by the annual influx of seasonal workers.

Approximately 60 per cent of the population of the region is within the potential labour force range (15 years and over). Of the estimated 7,450 in the potential labour force, 52 per cent were Indian and Eskimo; however, only 34 per cent of the natives are considered experienced or skilled labour.* Almost 55 per cent of the Indian labour force and about 58 per cent of the Eskimo labour force are involved in the traditional hunting and fishing and trapping life style. Those natives who are involved in the technical development of the Basin's non-renewable resources are mainly unskilled workers. The majority of the managerial, professional,technical and skilled jobs in both the resource and service industries are held by whites on a term or seasonal basis. It is expected that this situation will be significantly altered through native training programs.

The labour force statistics for seven communities in the Mackenzie Basin have been assembled (Table 1). These figures seem to bear out the preceding discussion.

6.3 Transportation

Although most communities are served by water transport throughout the summer months and, weather permitting, are linked by air throughout the year, access to some communities still remains a major problem (Fig. 11).

*Percentages are based on Statistics Canada estimates for the Northwest Territories in 1970.

Table 2. Commercial Facilities in Selected Communities in the Mackenzie Basin

Community	Population	Commercial Facilities							
		Airstrip	Fuel	Communications	Air Transportation	Water	Road	Power	Harbour
Aklavik	700	silt 2000 ft.	drums Imperial Oil	Telephone	daily from Inuvik	from Hay River $7/cwt	None	N.C.P.C. diesel 780 Kw. 12¢/kwh	None good site
Arctic Red River	90	ice 3000 ft.	drums Imperial Oil	Radio-telephone	from Inuvik bi-weekly	from Hay River $6/cwt.	None	N.C.P.C. diesel 12¢/kwh	good site
Fort McPherson	840	sand 3000 ft.	N.C.P.C.	Telephone Radio	from Inuvik daily 12¢/lb	from Hay River $2/cwt	None Highway to Inuvik and Dawson, Y.T. under construction	N.C.P.C. diesel capacity 750 Kw 12¢/kwh	summer
Fort Norman	260	graded sand 4400 ft.	Gov't. drums	Telephone Radio	4 x weekly from Norman Wells 9¢/lb	from Hay River $1.30/cwt	winter road to Mackenzie Hi-way	N.C.P.C. diesel 12¢/kwh	None
Fort Simpson	750	two: DOT (6000 ft.) Town (1500 ft.)	bulk Imperial Oil	Telephone Telex	from Edmonton 10¢/lb	from Hay River $1/cwt	from Hay River $4.60/cwt	N.C.P.C. 4 x 1225 kw 8¢/kwh	None
Tuktoyaktuks	610	Gravel 3500 ft.	bulk Imperial Oil	Telephone Radio	Inuvik 3 x weekly 15¢/lb	from Hay River $8/cwt	None	N.C.P.C. 450 kw 12¢/kwh	trans-shipment point between ocean vessels and barges.

FIG. 11
MACKENZIE BASIN
INTERGOVERNMENTAL SEMINAR
LAND TRANSPORTATION
1972

For several years, a road network has been under development to enventually provide year round ground linkage with southern Canada. Transportation and communication facilities for some communities of the basin are summarized in Table 2.

The Mackenzie River system provides a 1,600-mile navigable waterway from Waterways, Alberta to the Arctic Ocean, the only interruption being 12 miles of rapids on the Slave River between Fort Fitzgerald, Alberta and Fort Smith, N.W.T. A barge service operated by the Northern Transportation Company Ltd. runs from early May to late September. The company is the main carrier for supplies and equipment for recent oil exploration in the Basin.

The road network is at present confined to the southern part of the Basin (Fig. 11). Great Slave Lake is now linked to the south by the northern extension of the Alberta highway network. The two major highways of the Basin are the Mackenzie Highway, which has recently been completed to Fort Simpson, N.W.T., and the 390-mile Dempster Highway from Dawson, Y.T. to Fort McPherson, N.W.T. By 1974, the Dempster Highway will be linked to the Mackenzie Highway. An all-weather road has been constructed from Hay River to Fort Smith. A major road-building program was recently announced which will extend the Mackenzie Highway as far north as Inuvik.

The only rail link with southern Canada is the Great Slave Lake Railway, a 435-mile track from Pine Point, N.W.T. to Grimshaw, Alberta. It is primarily used to transport lead zinc ore concentrate from the Pine Point Mine to smelters at Trail, B.C.

Several communities in the Basin are served by two major commercial airlines connecting with southern Canada. Pacific Western Airlines connects Edmonton, Alberta, with the centers of Fort Smith, Yellowknife, Inuvik and Cambridge Bay. Transair operates from Winnipeg, Manitoba to Churchill, Manitoba, and to Yellowknife, N.W.T. There are also nine air charter services operating within the Basin (Fig. 12).

Due to the importance of air transportation, airfields and airports are being reconstructed and modernized under the Northern Airports Program. In many cases, however, any development regarding roads, railways and airstrips is hindered by the problem of permafrost.

In addition to these forms of transportation, the C.B.C. Northern Service provides short and standard wave radio service to all communities and is now operating a television station in Yellowknife using video-taped programs. A CN-CP telecommunications network serves the Basin via Edmonton, Alberta, and Hay River, N.W.T. A land line provides voice and radio communication between Hay River, Inuvik and points along the Mackenzie River. Another line connects settlements on the north and south shores of Great Slave Lake and Uranium City, Saskatchewan. Development of a domestic satellite communication system is now underway to supplement the existing telecommunication network.

6.4 Community Development

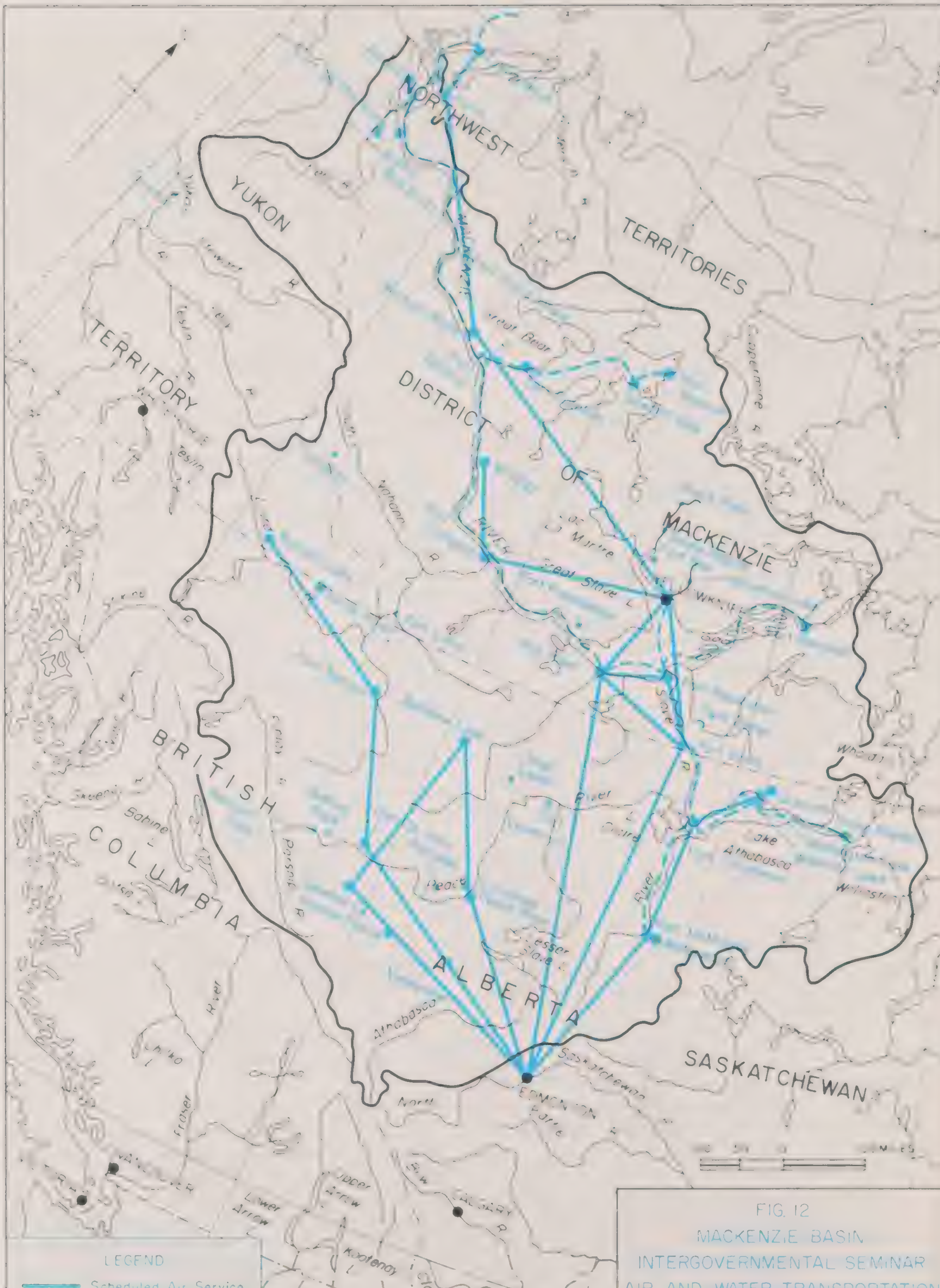
Communities in the Basin are supplied with electricity mainly from hydro and diesel-electric generating stations of the Northern Canada Power Commission facilities. The fuel required is supplied by the refinery at Norman Wells either by barge or, in the Great Slave Lake area, by truck and rail service. The usual high level of permafrost, poor drainage conditions and adverse climatic conditions cause many problems for building construction and utilidor development. Utilidors (heated and elevated or underground recirculating distribution) were built for water, sewer, communications, steam and power lines. When possible, utilidor construction underground is less costly than other alternatives. In construction, the size, weight, and utilization of the building along with type of soil underneath it will dictate the type of foundations to be used such as concrete pilings, timber posts, and concrete or gravel pads. Housing improvements are encouraged by loans from the Central Mortgage and Housing Corporation in Yellowknife, and other similar government housing programs.

Medical services, provided by the Department of National Health and Welfare, range from hospitals in the larger centers to dispensaries in smaller centers.

The native population is encouraged to form co-operatives; for example, fishermen's co-operatives on Lake Athabasca and Great Bear Lake have been established.

The territorial and federal governments fund such projects as road construction, housing and airstrip improvements.

Educational facilities are steadily improving with most communities having primary schools, some junior high schools, and larger centers like Yellowknife and Fort McMurray having secondary schools and centers for vocational training. Special training and correspondence courses are offered, and bursaries encourage natives to attend universities in southern Canada.



LEGEND
Scheduled Air Service
Shipping Service

FIG. 12
MACKENZIE BASIN
INTERGOVERNMENTAL SEMINAR
AIR AND WATER TRANSPORTATION
1972

HISTORICAL SIGNIFICANCE

- Traditionally, Indians and Eskimos of the Mackenzie Basin have practiced a nomadic hunting and gathering way of life, dependent on the fish and wildlife resources to provide necessities of life.

Exploration

- Explorers like Mackenzie and Hearne were hired to seek out the area's fur riches (in 1700's and 1800's).
- Fur trade shifted to the Mackenzie in late 1800's, establishing trading posts and missions giving rise to new settlements along major waterways.
- Indians and Eskimos began to settle near these settlements.

Development to Present

- Mackenzie River Transport Company established to transport furs southward; later carried finished goods and supplies northward
- Barge traffic increased dramatically with discoveries of oil at Norman Wells, (1920's), gold at Yellowknife and radium at Port Radium in 1930's
- These discoveries caused a great influx of white people, facilitating the need for Northern Transportation Company Limited in 1934
- War years spurred the building of Alaskan Highway, Canol Project and several airfields
- Discoveries of uranium and base metal deposits near Great Slave Lake attracted more people in late 1940's
- Mackenzie Highway extended to Yellowknife in 1950's
- Beginning of a trunk road system being greatly expanded over next 20 years
- Recent oil and gas activity in the north has increased barge traffic

DEMOGRAPHY

- 1970 estimate of 234,000 in Mackenzie Basin

Larger centres	1971 population
Yellowknife	5867
Fort Smith	2372
Inuvik	2672
Hay River	2420
Fort Nelson	2281
Fort St. John	8243
Dawson Creek	11488
Fort McMurray	6749
Grande Prairie	12797
Hinton	4916

- Population density — 1 person to 50 square miles versus Canada's average of over 5 persons per square mile
- Present population characterized by large group in 0-4 year group and low percentage in over 60 year group
- 60% of population within potential labour force range (15 to 60 years old)
- Although Indian and Eskimo represents 52% of labour force (N.W.T.), the majority are unskilled workers

DEMOGRAPHY (cont'd)

- Managerial, professional, technical and skilled jobs in both resource and service industries held by whites on term basis
- Since 1961, total population has increased by 43%, the white population by 83%

TRANSPORTATION & COMMUNICATION

- Water: barge service operated by NTCL and Kaps Transport from Waterways, Alberta 1600 miles north to Tuktoyaktuk from early May to late September
- Road: road system confined to area around Great Slave Lake, which is an extension of the Alberta system
- Winter roads link communities and exploration sites
- Dempster Highway from Dawson to Fort McPherson by 1974 to be 390 miles long
- Mackenzie Highway now 695 miles long from Grimshaw to Fort Simpson and eventually will reach Inuvik and Tuktoyaktuk under 20-year plan
- All weather road from Hay River to Fort Smith will soon link Uranium City
- All weather roads planned to link Tuktoyaktuk, Inuvik to Fort McPherson
- Rail: Great Slave Railway — only link, north of 60° latitude — 435-mile link carrying ore from Pine Point to Grimshaw and on to smelters in Trail, B.C. via the Northern Alberta and B.C. trunk system
- Air provides only link for several northern communities
- 2 commercial airlines, Pacific Western and Trans Air plus 9 charter services operate in the basin

Air Routes

Centres Linked	Distance (miles)	Scheduled
Edmonton to Fort Smith	425	yes
Edmonton to Yellowknife	600	yes
Yellowknife to Fort Smith	192	yes
Yellowknife to Norman Wells	410	yes
Norman Wells to Inuvik	277	yes
Fort Smith to Hay River	142	no
Hay River to Fort Simpson	192	yes
Fort Smith to Fort McMurray	234	no
Grande Prairie to Fort St. John	102	yes
Fort St. John to Fort Nelson	192	yes
Fort Nelson to Watson Lake	236	yes

- Area served by CN/CP Telecommunications from Edmonton and Hay River with links to Uranium City, Fort Smith and Yellowknife
- CNT line provides voice and radio transmissions between Hay River and Inuvik and points along the Mackenzie plus links to Aklavik and Tuktoyaktuk
- Both short-wave and standard radio provided by CBC Northern Service to all communities
- Video-tape television being expanded from Yellownife TV station

COMMUNITY DEVELOPMENT

- Power supplied to communities mostly by small oil-fired thermal generating plants, average size between 500 and 1000 kilowatts
- Sewage and water services supplied by use of utilidors
- Housing improvement encouraged by CMHC loans from headquarters in Yellowknife and through various governmental housing agencies such as the rental program being administrated by the Territorial Housing Division, supplying 2,350 units by the end of 1971, while yet requiring 850 units, statistics for N.W.T.
- Medical services provided by National Health and Welfare ranging from hospitals in larger centres to dispensaries in smaller ones
- Cooperatives encouraged among native — e.g., fishermen's coops on Lake Athabasca and Great Bear Lake
- Government and community projects such as road construction, housing projects like the 17-unit NHA Senior Citizen's apartment building completed in 1970 at Yellowknife, and improvement of airstrips
- Education facilities steadily improving with most communities having primary schools, some junior high schools and larger centres like Fort Smith, Fort McMurray and Yellowknife secondary schools and centres for vocational training, N.W.T. enrolment in grade school for 1971-72 was 4375 Eskimo, 1845 Indian, and 4828 others, in 1970-71 there were 1375 vocational trainees, N.W.T.
- Special training and correspondence courses offered
- Continuing and special educational enrolment within N.W.T. is 482 Eskimo, 283 Indian, and 433 others, and for Territorians outside N.W.T. these figures are 112, 32, and 73 respectively (data for 1970-71)
- Bursaries offered to natives to go to universities in the south

Alberta

Mackenzie River Basin: The Alberta Component

WATER RESOURCES DIVISION,
ALBERTA DEPARTMENT OF THE ENVIRONMENT

Contents

Illustrations

Mackenzie River Basin: the Alberta Component

1. INTRODUCTION

About 23 percent, or nearly one quarter of the Mackenzie River Basin lies within Alberta and occupies about 64 percent of the province. This portion consists of the Athabasca River, about 61 percent of the Peace River System, a portion of the Hay River, and a small tributary to the Liard. In terms of water volumes, Alberta contributes in the order of 2,000,000 acre-feet per year to the Hay River, and approximately $34^1/_2$ million acre-feet per year by way of the Peace-Athabasca System (Fig. 1).

To date there have been no water management projects undertaken on these river systems in Alberta; however, several possibilities are recognized for hydro power development, and for use of Mackenzie River Basin water to augment supplies in the Saskatchewan River System to meet future demands in Alberta, and possibly in Saskatchewan and Manitoba.

2. HYDRO-ELECTRIC POWER

Original reconnaissance of hydro power potential on the Peace River was carried out prior to 1916. In 1963 an aerial reconnaissance, followed by on-site inspection, reduced the number of suitable locations under present-day criteria to three. The first site is located at Dunvegan about 79 miles east of the Alberta-British Columbia boundary which has a potential of some 700,000 hp. A second site located about 107 miles downstream from Peace River Town also has a capacity of approximately 700,000 hp. River bank stability at this latter site is questionable however (Fig. 2).

The location that appears to hold the most promise at the present time is known as the Mountain Rapids Site located on the Slave River about 10 miles south of the Alberta-N.W.T. boundary. Although it has a lesser head than the other two sites, its estimated potential output is in the order of 1.4 million hp, and due to the large supply of water that would be available, the output in terms of kilowatt hours could be significant. Depending on the full supply level that might eventually be determined if the site receives future serious consideration, this project could have an influence on water levels in the Peace-Athabasca Delta and Lake Athabasca.

Preliminary investigations on the Athabasca River suggest possibilities for hydro power development between Lesser Slave Lake and Fort McMurray by a series of five dams. The first of these would be the Mirror Site located a few miles upstream from Athabasca Town (Fig. 3). It could provide some one and one-half million acre-ft. of storage which together with an additional one and one-half to three and one-half million acre-ft. of storage on Lesser Slave Lake would provide the necessary downstream flow regulation. The construction of four additional dams located at Pelican Rapids, Grand Rapids, Boiler Rapids, and at Fort McMurray, would collectively produce a total head of 1130 ft., producing an annual output of eight billion kilowatt hours. The total installed generating capacity in the five plants would approximate 200,000,000 hp. None of these sites are under active investigation at the present time.

If power development was also considered in conjunction with certain water diversion possibilities which will be discussed later, the estimated potential available hydro power on the Peace-Athabasca System, including the Mountain Rapids Site on the Slave River, amounts to some 29 billion kilowatt hours per year.

3. WATER SUPPLIES

A factor that may become significant in future water utilization plans is the fact that about 80 percent of Alberta's flowing water resources are to be found in that portion of the province which is contained within the Mackenzie Watershed, whereas approximately 80 percent of Alberta's population is located in the southern half of the province.

There would appear to be two alternatives for the remedy of this imbalance. Encourage people to move where the water is, or move the water to where the people are. At the present, practical methods for ensuring a transfer of population densities are limited; however, some consideration can at least be given to the feasibility of moving the water.

The topography of the province is such that this can be accomplished through gravity diversions, beginning in the southern part of the province and progressively tapping additional supplies of water from rivers to the north.

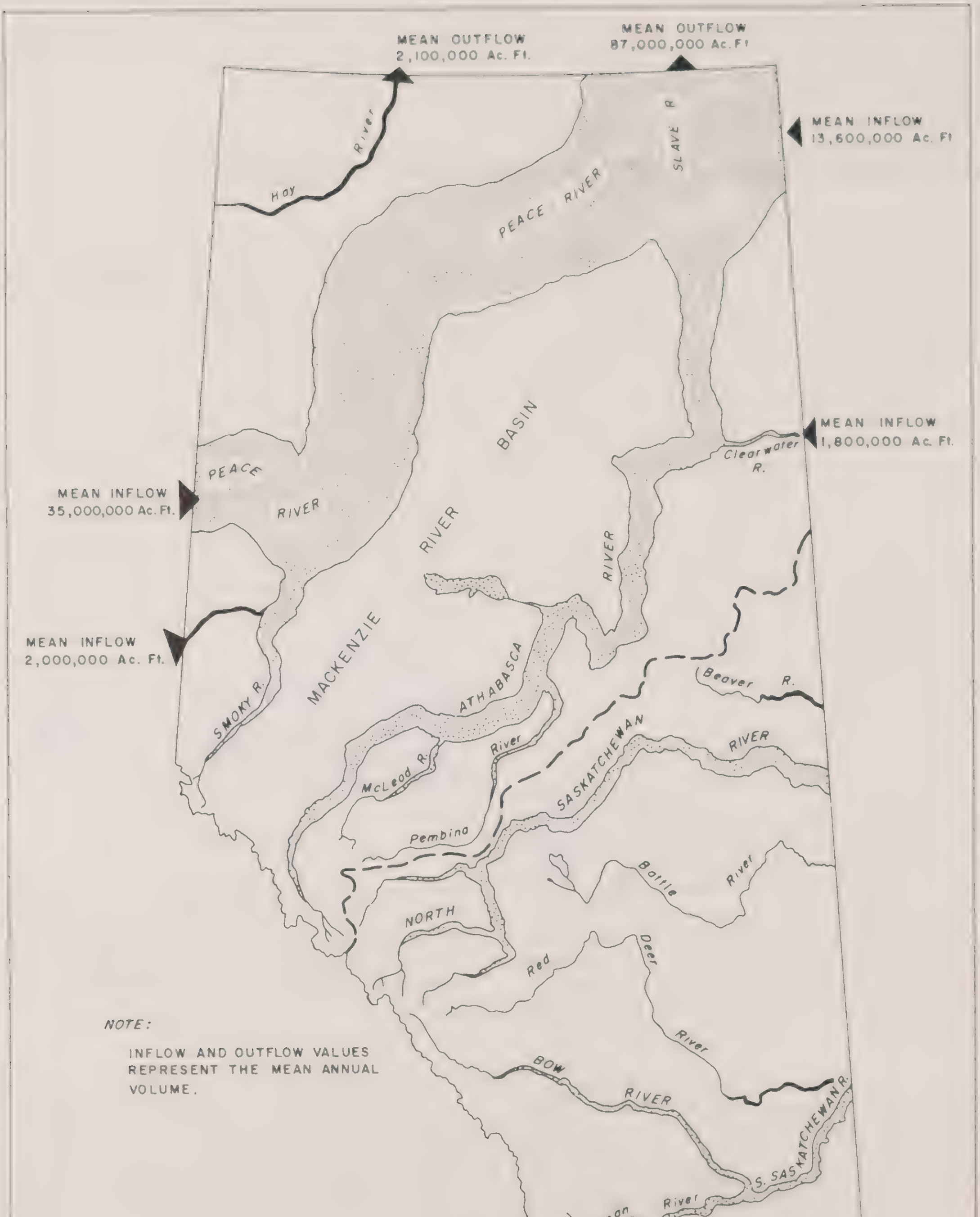


Figure 1. Relative Magnitude of mean river discharges.

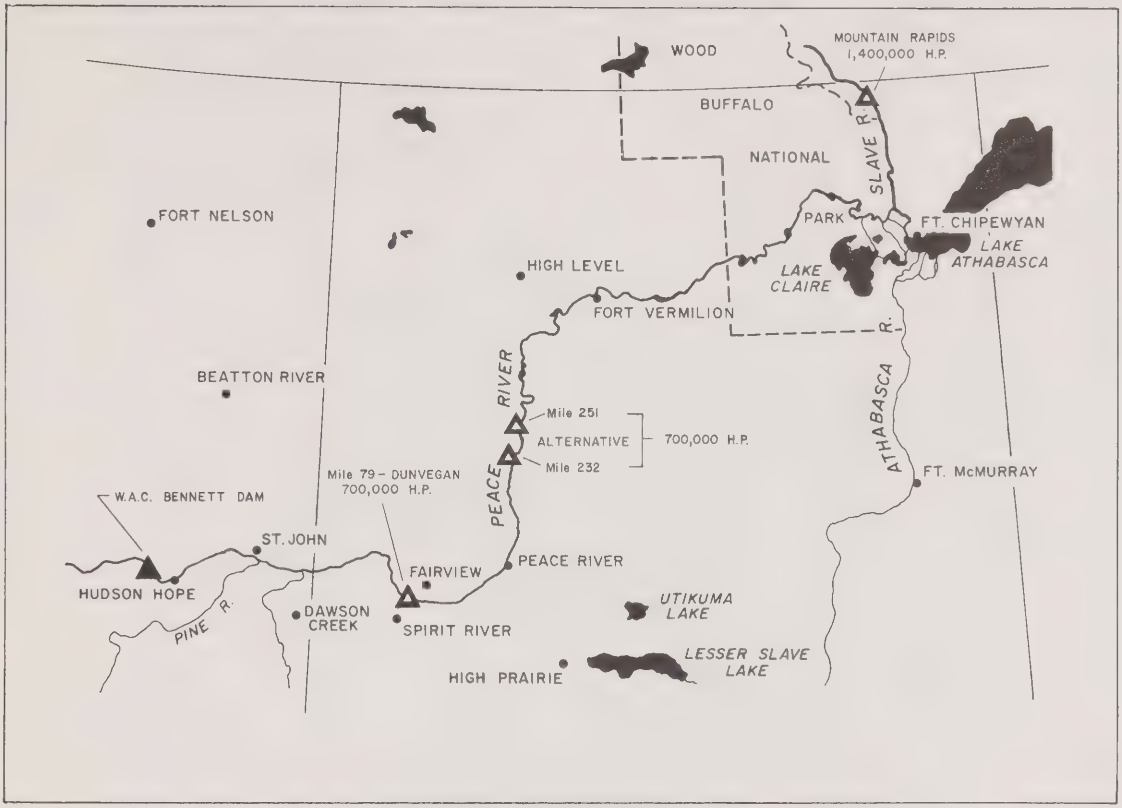


Figure 2. Power Possibilities – Peace River.

However, each diversion robs the donor river of water which might well be needed in the future because of growing demands in the region served by that river. It may therefore not only become necessary to replace the borrowed water by a further borrowing from a more northerly river, but also the additional augmentation of supplies to some degree may become a necessity. Eventually this progressive borrowing of water will reach the northern extremity of the Saskatchewan River Watershed and any further source of supplies can only be obtained by tapping those waters in the Alberta portion of the Mackenzie Basin.

When, or if, this will become a justifiable alternative, is a matter of speculation at this point in time. The current policy of the Alberta Government does not embrace plans or programs for water diversion from the Mackenzie Basin to the Saskatchewan-Nelson Basin. The possibility cannot be overlooked however, even though the time of reality may be so far into the future that those of us here today will not have to be concerned with that decision.

A second factor which might influence the need to tap the Mackenzie Basin rivers lies in the fact that, in addition to Alberta, the Provinces of Saskatchewan and Manitoba depend on the Saskatchewan River System. One means of increasing water supplies to those areas would be by northern Alberta diversion of Mackenzie Basin water into the Saskatchewan System.

4. CURRENT STUDIES

Because of the magnitude and complexity of studies related to water supply projects, it is self-evident that these studies should be undertaken well in advance of the time when anticipated future needs become a reality. One of the first and essential ingredients in any such studies is an inventory of the resource, and potential alternatives available. In 1963 such an inventory was initiated by the provinces of Alberta, Saskatchewan and Manitoba, and the government of Canada, by way of the current Saskatchewan-Nelson Basin Study. The basic objective of

Figure 3. Power Possibilities – Athabasca River.

this undertaking was "to study the water resources of the Saskatchewan-Nelson Basin including the potential additional supply by diversion or storage".

Accordingly, part of the study included consideration of several possibilities for the diversion of water from the Mackenzie System to the Saskatchewan River System (Fig. 4). For analysis purposes, the water to be diverted was assumed to range from a minimum of 2,000 cfs to a maximum of 30,000 cfs using various combinations of the projects identified. It was also assumed that:

1. The diversion period of each site would be seven months, extending from the middle of April to the middle of November.

2. All reservoirs would be maintained as close as possible to their full capacity.

3. Minimum allowable downstream flows could be released at all times since reservoirs would be large enough to satisfy both riparian and diversion requirements.

In addition to considering the engineering feasibility of these possibilities, a preliminary assessment was undertaken to determine the effects of such diversion with respect to morphology, water quality, navigation, ecology and wildlife, fisheries, and hydro-electric power. The main purpose of this appraisal was to identify and "flag" certain consequences that should be given more in-depth study if the need to seriously consider such projects were to arise in the future.

The conclusions reached were that diversions from the Athabasca-Mackenzie Basin, combined with normal operation of the Bennett Dam, would create problems for most of the activities and resources in the basin (Fig. 5). The items most directly affected would be navigation, wildlife and fisheries. The problems created for these items were attributed more to seasonal levels and peak flows, than to total annual runoff values.

Diversions from the Athabasca would have serious implications, particularly for navigation, and would compound the conditions currently being experienced on

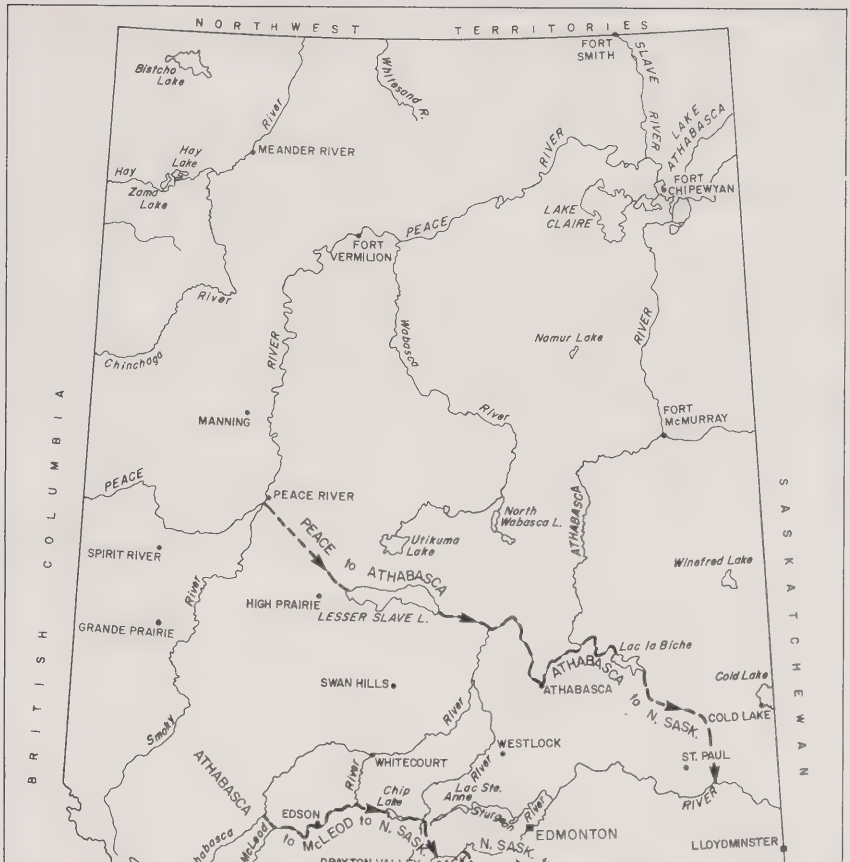


Figure 4. Possible north-south interbasin diversions.

Figure 5. Athabasca – Mackenzie Basin – general plan.

Lake Athabasca. It was anticipated however, that the effects downstream from Lake Athabasca would be less serious since the predicted reduction in water levels under the combined influence of the Bennett Dam and the diversion of 30,000 cubic feet per second, would be generally less than 10 percent of the river's depth. However, these effects may nevertheless be of sufficient magnitude to cause concern for navigation interests on the Slave and Mackenzie Rivers.

Morphological changes in the vicinity of the diversion dams could be of some consequence and seriously affect the spawning and migration pattern of fish species in the rivers. Downstream, the morphology of the outlet channels from Lake Athabasca could change significantly because of reduced flows in the Peace and Athabasca Rivers, resulting in further lowering of lake levels.

Downstream of Lake Athabasca, morphological effects would be of a minor nature due to the lower percentage of flow reduction and the more stable nature of the river beds.

Although slight changes could take place, no extensive alterations in overall water quality would be expected to result. A decrease in river flows could cause some reduction in the rate of nutrient inflows to the lakes of this system, but it is not presently known if the effects on lake fisheries would be significant.

The level of stratification that would occur in the diversion reservoirs is not expected to affect aquatic life within or downstream of the reservoirs to any great extent; however, studies should be carried out to determine how these impoundments will affect aquatic life at these northern latitudes. The ecology of the river floodplains and deltas is dependent on high annual spring flooding. It is probably that the height and timing of the flood peaks are relatively more important than the overall volume and

duration of flooding. It was also noted that some benefits could be derived from slightly higher autumn levels if they were held reasonably constant throughout the winter.

The area that could be most severely affected by diversions would be the Peace-Athabasca Delta, which has already undergone recent significant changes. While wildlife resources in the Slave and Mackenzie deltas and on the river floodplains would be affected by changes in river flows, the extent of change would be much less than that in the Peace-Athabasca Delta.

The overall effect that diversions would have on the fisheries of the basin, is unknown. The principal fisheries of the area are currently on Lake Athabasca and Great Slave Lake. A major factor in the productivity of these fisheries is the relatively low overall nutrient levels in the lakes. As nutrients in the form of dissolved solids are supplied to the lakes by the inflowing rivers, it would be expected that flow reductions in the rivers would reduce nutrient levels to some extent; however, whether this reduction would be significant cannot be presently determined.

Diversions from the Peace River System would allow the introduction of undesirable fish species into the Athabasca and Saskatchewan Rivers.

With respect to the effects of diversions on possible power development, it was found that up to one-quarter of the total power potential could be lost if the diversions assumed were in fact implemented.

As a result of these findings it is generally apparent that extensive additional studies of all the various effects of diversion on the basin are required. These studies will be needed to properly assess the value of the resources in the basin, the effects of diversion on them and their relative place in any overall water management scheme. Compensatory measures should be assessed for their ability to mitigate detrimental effects. An initial requirement would be the development of a more comprehensive data collection system. Development of such a system should be undertaken through cooperation among all agencies who have an interest in the basin. This will hopefully ensure that all the data required are gathered and analysed in a manner compatible with individual agency needs.

Once basic data are available, the detailed studies required should be undertaken cooperatively by the individual agencies. Concrete proposals for optimum water management can then be developed and the fullest possible advantage taken of the available resources of the basin.

It is accordingly highly desirable that early steps be taken to initiate studies so that there will be a sufficient time period for development of a management scheme prior to any implementation of water projects. It should be noted that even if water is not diverted, substantial benefits would be realized from the development of a water management plan.

5. OTHER RESOURCES

Northern Alberta also contains other natural resources, the utilization of which can have an influence on the waters of the Mackenzie System. The harvest of forests continues to be an active industry. Oil exploration and recovery is predominant in the Swan Hills south of Lesser Slave Lake. Every consideration is being given to ensure that these activities are carried out in a manner compatible with good environmental management. Water pollution control, proper forest husbandry and nondestructive land use practice criteria are being applied. New improved criteria are being developed.

The potential of the Athabasca Tar Sands is well recognized. Currently there are two major studies underway relative to this resource, one of which pertains to the environmental impact of large-scale oil extraction, including the utilization and preservation of quality of the Athabasca River.

6. CONCLUSIONS

In conclusion, should there be any misunderstanding, it must be emphasized that Alberta has no firm foreseeable plans for implementing any hydro-power or water diversion projects in the Mackenzie Basin. Although certain potential possibilities have been identified, no demands or requirements exist at the present time. Nor is it known for sure that such requirements will exist in the future, but if there be any chance that they might, it is appropriate that we begin now to prepare for the decisions that will have to be made at that time.

The Mackenzie Basin is the seventh largest watershed in the world. Twenty-three percent of the upper reaches of this watershed is located in the Province of Alberta. Were it not for the recognition that, where environmental matters are concerned, political boundaries must be discarded, it might be said that Alberta occupies an enviable position. However, the reverse may more likely be true since any major water projects undertaken in Alberta will result in some degree of downstream effects to the ecology and natural environment, as well as a possible impact on economic developments — navigation for example. If we are to exercise conscientious concern for these things, it is

recognized that thorough in-depth studies and planning are prerequisite to any major developments.

Alberta is prepared to extend assistance and co-operation where possible in a joint undertaking with all other jurisdictional agencies in the planning for future resource development. The Mackenzie Basin is one of the few remaining nearly virgin areas of the world. Let's heed the errors of past civilization and this time do a proper job from the beginning.

Arctic Transportation Agency

Mackenzie River Basin: Transportation

ARCTIC TRANSPORTATION AGENCY

Mackenzie River Basin: Transportation

The Ministry of Transport's interest in the management of the Mackenzie River Basin arises from the Ministry's objectives with respect to ensuring that transportation services respond to the developing needs of the area. The Ministry provides and maintains a system of air travel and way facilities throughout the basin but these are not related to the matter at hand.

The Mackenzie River Basin as an inland water route has and will continue to play a significant role in the development of the northern portions of the Provinces of Alberta and Saskatchewan and the western portion of the Northwest Territories.

During the 1970 season 311,000 tons of cargo were transported and in 1971 this increased to 325,000 tons. More than 50% of this cargo is bulk petroleum products. The 1970 cargo was transported by a fleet of 116 barges, 17 tugs and a cargo ship. The barges ranged in size from 24' x 75' to 80' x 250' with capacities from 75 tons to 1500 tons.

The principal carrier operating on the Mackenzie River is Northern Transportation Company Limited, a Crown Corporation (proprietary) responsibility to the Minister of Transport, which provides a general transportation system for the movement of goods by water in the Western and Central Arctic and the Mackenzie Basin. The Ministry of Transport controls its budget and the Canadian Transport Commission regulates its equipment, its franchises and tariffs. Northern Transportation Company Limited carries approximately 90% of the marine cargo tonnage shipped in this area.

Kaps Transport is the second largest carrier and there are three other small carriers licensed to do commercial business.

The productive capacity of the equipment used for Marine Transportation is reduced considerably because of the shallow water and rapids on the river. In 1970 the maximum draft achieved even considering high water periods was only 60% of the design capacity.

The areas critical to navigation on the Mackenzie, in order from Great Slave Lake, are:

Beaver Lake

This is an area of little current but of shallow water. Navigation channel is in the order of 5 to 8 feet in depth.

Providence Rapids

Water depths are of 15 to 25 feet but with a fast current, generally about 6 mph but indications up to 11 mph.

Green Island Rapids

Narrow and intricate channel, current to 6 mph.

Black Water

For several miles current is strong and turbulent, flowing 6 to 8 mph.

Sans Sault Rapids

There are boulder shallows; water depths are 4 to 8 feet; current is 3 to $4^1/_2$ mph with many bottom hazards.

Ramparts Rapid

During periods of low water, a distinct drop forms over a distance of about 500 yards through which current flows 6 to 7 mph.

Although the rock-formed rapids of the Sans Sault with its fast waters has in the past imposed the most serious navigation difficulties and extreme operating hardships, the real capacity of the equipment and the river system is dictated by channel conditions in the first three sections mentioned. Because of their geographical location in the Mackenzie River close to Great Slave Lake and the shipping terminal at Hay River, they affect the permissible draft loading of the barges and consequently determine the logistic capacity of the system.

Another result of the limitations of these channels is the time required to break up tows in order to relay single barges through these trouble spots and on occasion even lightening to negotiate passage. This again seriously affects the efficiency of the existing equipment. The fast waters of Ramparts, Blackwater and Providence Rapids are serious obstables to upstream navigation.

A continuing program of river maintenance has been carried out by the Department of Public Works. Expenditures for maintenance for the period 1967 – March 31, 1972 have been $1,407,418.00. The Ministry of Transport maintains the aids to marine navigation at an annual cost of $170,000 to 200,000.

The objective of this program is to develop and maintain a 6-foot channel in the soft areas. No attempt has been made to re-orientate the channel by widening or straightening out the bends. Over the past three years, the Sans Sault Rapids channel has been improved at a cost of $2,869,455.

Last year the Department of Public Works commenced a major survey of the river which was scheduled to take three years. Additional funds have been provided to enable the survey to be completed this year. This will enable accurate estimates of the cost of further improving the channel by widening on the turns, straightening out the bends and deepening the channel to 8 feet, and the completion of an assessment of the economics of increasing the capacity of the waterway.

An in-depth environmental study of the dredging program has not been made; however, one analysis suggests that suction or bucket dredging would have little impact on fish and wildlife, but with blasting there would be some local damage to fish. However, as the blasting would occur at widely separated points the impact on total fish life would be relatively minor. The enlarging of the stream cross section would tend to decrease total stream velocity by a small amount. Any effect from this decrease would tend to improve fish life by the elimination of rapids hazards and by providing stiller water entrances to places for propagation. Any increase in flow in the dredged channel would tend to reduce the wash at the shore line.

Mention should also be made of the Liard River, which in conjunction with the extension of the British Columbia Railway some 80 miles from Fort Nelson to Nelson Forks would provide another route into the Arctic. Dredging considerations are a key factor in any decision to provide an additional route and these have yet to be assessed. However, in terms of water transport the advantage of the use of the Liard is that it opens to navigation at least two weeks earlier than tugs can get out of Hay River due to ice on Great Slave Lake. This, however, may be more than offset by the shallow water later on.

British Columbia

Mackenzie River Basin: British Columbia Section

BRITISH COLUMBIA WATER RESOURCES SERVICE

Contents

Preface

In accordance with agreements reached during a meeting held at Edmonton, Alberta on April 27, 1972, with representatives of Canada, Saskatchewan, Yukon Territory, Northwest Territories, Alberta and British Columbia, a working paper has been prepared for a seminar on the Mackenzie Delta to be held at Inuvik in June 1972.

This working paper, which forms part of an exchange of information between the participants at the seminar, outlines the possibilities of water resource developments on tributaries to the Mackenzie River located in British Columbia, possible effects of these developments downstream and the need for intergovernmental consultation or action.

Mackenzie River Basin: British Columbia Section

1. LIARD RIVER

1.1 Development Possibilities in British Columbia

Preliminary studies are being carried out by the Water Resources Service of the Department of Lands, Forests and Water Resources of British Columbia, on potential of damsites located on the main stem of the Liard River in British Columbia, with a first aim to determine hydro-electric potential.

The Liard River has, at its confluence with the Mackenzie River, a total drainage area of approximately 105,000 square miles, of which some 54,000 square miles are located in northern British Columbia. The remainder of the drainage area is located in Yukon Territory, Northwest Territories and Alberta, draining areas of about 23,700, 24,000, and 3,300 square miles respectively.

A preliminary report prepared by the Water Investigations Branch in July of 1970, investigated the storage and power sites located on the main stem and selected a preliminary optimum scheme for large-scale hydro-electric development considering only power production. Associated water management aspects, environmental impact, including downstream effects, were not considered in this preliminary analysis. An outline of the findings of the July 1970 report follows.

The scheme of development would consist of a series of three dams, A, E and G, located as shown on the attached Key Map. Studies made subsequent to the report indicate that it is unlikely that Damsite X, located downstream of the selected sites, is an economically attractive addition to possible upstream development schemes.

Damsite G, the uppermost site, provides about 70 percent of the live storage required to fully regulate the river and produces an average prime flow of 21,550 cfs at this site. Damsite E regulates the drainage area between Sites E and G to increase the average prime flow to 34,350 cfs. Damsite A, which provides about 5 percent of the live storage in the scheme, regulates the inflow from the tributaries between E and A and increases the average prime flow at this downstream site to 37,590 cfs.

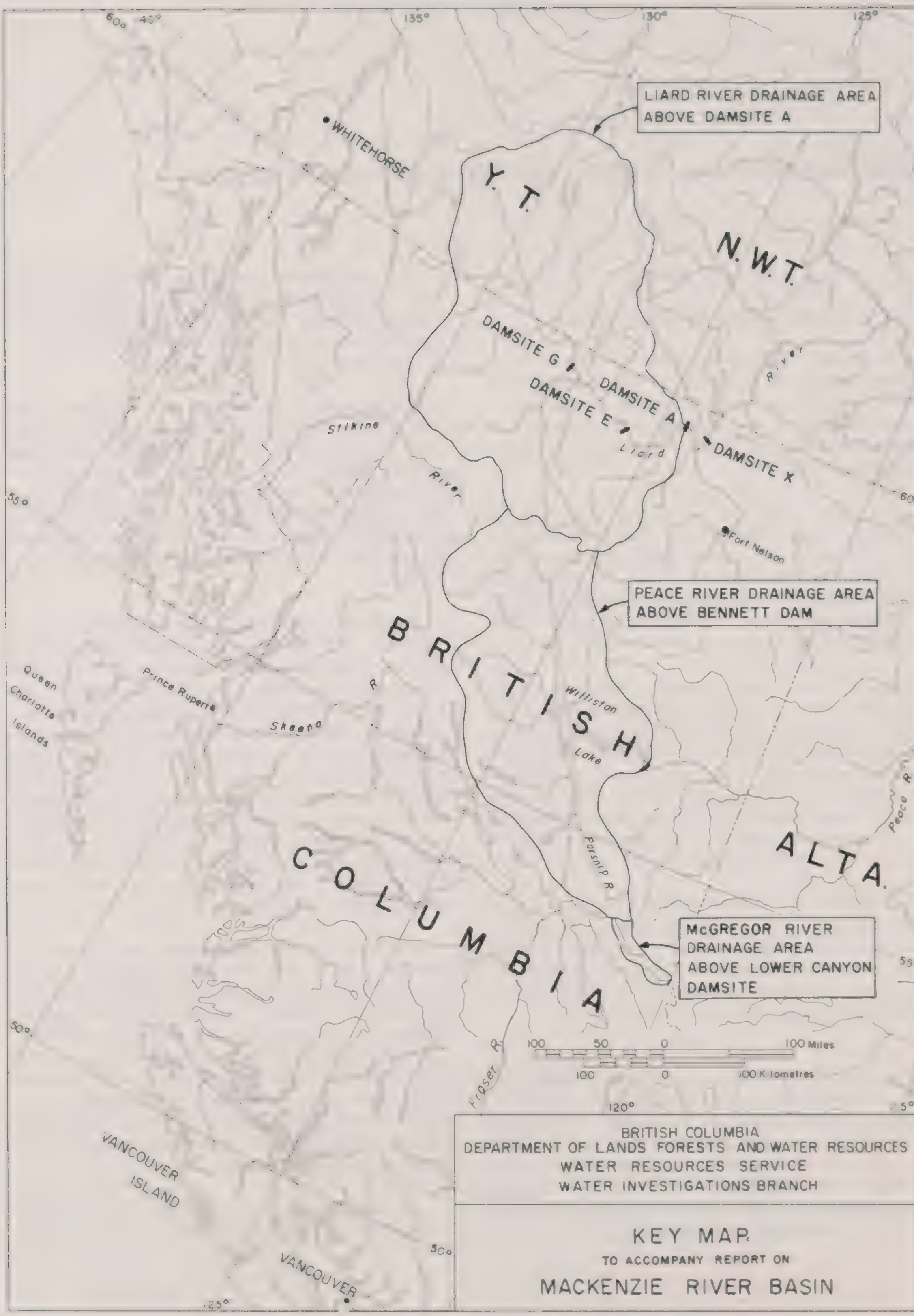
The basic potential hydro-power characteristics of the scheme selected in the July 1970 report are shown on the attached Summary Table. The system is expected to produce a total of 2,245 MW prime power and have a total installed capacity of 7.5 million horsepower.

The proposals would inundate some 160 miles of the Alaska Highway and require access roads to Watson Lake after filling of Reservoir G. Development costs have included allowance for these items as well as provision for the relocation of Lower Post. Liard Hotsprings Provincial Park at Lower Crossing would be inundated by impoundment at Site E. Out of a total reservoir surface area of some 260,000 acres, some 27,000 acres lie within the Yukon Territory.

Several other alternative sites on the main stem of the Liard River in British Columbia are being investigated for a two-dam power development scheme. The alternative schemes would have little, if any, effect on the river levels in the Yukon Territory and one proposed scheme under investigation would eliminate flooding at Liard Hotsprings Provincial Park. It is expected that continuous power production for the two-dam alternatives will be somewhat less than for the scheme selected in the July 1970 report and power costs may be slightly increased. Basic geological exploration including diamond drilling of abutments and material surveys may be required should these latter studies indicate that the sites under investigation are attractive alternatives to those investigated in the July 1970 report.

The power schemes outlined above could possibly be enhanced if the Frances River power sites located in the Yukon Territory were developed and operated as part of the Liard River system. It should be noted that results of the Liard River studies have been utilized by the British Columbia Energy Board in its appraisal of power sources available to the Province. Results of the British Columbia Energy Board study are expected to be available later in 1972 and will indicate whether the Liard River power potential is recommended to meet British Columbia's load growth in the next two decades.

As mentioned above, the investigations to date by the Water Resources Service, have dealt with hydro-electric



BRITISH COLUMBIA
DEPARTMENT OF LANDS FORESTS AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH

KEY MAP
TO ACCOMPANY REPORT ON
MACKENZIE RIVER BASIN

power development only. The effect of the proposals on other resource users was given only cursory examination.

1.2 Effects on Other Users

Flow regulation as a result of main stem power development in British Columbia, would have an effect on downstream navigation on the Lower Liard River and, to a lesser extent, on the Mackenzie River. During the ice breakup period in May of each year, the reservoirs would be storing water and this may delay the downstream breakup somewhat. In the high flow summer months, the reservoir storage would reduce the flood flows to the benefit of downstream navigation. In the late part of the season for navigation on the Liard, which ends usually in mid-August to mid-September, the effect on navigation would vary depending on natural flow conditions. It is considered that the adverse or beneficial effects of reservoir regulation on fall flows are not likely to be of great significance.

A critical section for navigation on the Liard River is the Liard Rapids, a 13-mile stretch located in the Northwest Territories from 35 to 48 miles upstream of Fort Simpson. About one-third of the natural flow at this point would be affected by dams located upstream on the main stem of the Liard River. The rapids are comprised of a series of riffles, a fall of about 80 feet being scattered over the 13-mile reach. During high water, usually in June and July, the current is reported to be very strong. By about the end of August, the water in the rapids is too shallow for the existing barges which have a two to three-foot draft. The reach also appears to prevent Mackenzie River barges of about six-foot draft from navigating the Lower Liard.

The importance of ecological problems associated with the development of these major reservoirs was recognized but not evaluated for the preliminary studies carried out at this time.

2. PEACE RIVER

2.1 Portage Mountain Development

The Portage Mountain Development at the Peace River Canyon, owned by the British Columbia Hydro and Power Authority, is located on the Peace River near Hudson Hope in British Columbia, as shown on the Key Map. The headwaters of the 27,000 square-mile drainage area lie in the Rocky Mountain Trench which is drained from the north by the Finlay River and from the south by the Parsnip River. The Peace River, which originates at the junction of the Finlay and Parsnip, flows eastward through the Rocky Mountains and continues across the interior plains to become the Slave River and eventually the main stream of the Mackenzie River.

This development is among the larger hydro-electric projects in North America, having a reservoir storage capacity of 57 million acre-feet, a dam height of 600 feet, and an ultimate capacity of underground power facilities of 2,270 MW. The long-term annual discharge at the site is 36,500 cfs.

A potential run-of-river power site, so-called Site 1, is located a short distance downstream from the existing dam and has been under active study.

The British Columbia Government is not in a position at this time to discuss the downstream effects of this development as these matters are the subject of two court cases involving an agency of the Government of British Columbia.

2.2 McGregor River Diversion to Peace River

The McGregor River rises in the northeastern part of the Fraser River basin, which lies on the western side of the Rocky Mountains near the British Columbia-Alberta border.

The river initially flows in a northwesterly direction, passing through the McGregor Range at Lower Canyon and finally joining the Fraser River near Hansard, as shown on the attached Key Map.

Studies conducted by the federal-provincial Fraser River Board and published in the Final Report of 1963, indicated that a diversion of the McGregor River to the adjoining Parsnip River located in the Peace River drainage area would provide flood-control benefits to the Fraser River system. In addition, energy benefits would accrue at the Portage Mountain Power Plant on the Peace River and at sites downstream in the Peace River system.

The diversion would add approximately 4.8 million acre-feet of water annually to the Peace River reservoir, equivalent to 18 percent of the Peace River inflow.

Further studies and field investigations of the Lower McGregor diversion scheme are currently underway as part of the review of upstream storage under the federal-provincial Flood Control (1968) Agreement. One of the aspects under investigation is the physical feasibility of the scheme.

The Lower McGregor diversion scheme is also being considered by the British Columbia Energy Board in its appraisal of power sources available to the Province.

Potential Liard River Power Development

Site No.	Function	Volume Earth Fill Dam (cu.yd.)	Operating Reservoir Elevations		Drawdown Max. (ft.)	Live Storage Capacity (ac.ft.)	Average Prime Flow (cfs)	Turbine Design Head (ft)	No. of Units	Total Install. Capacity (HP)	Total Generator Rated Output (MW)	Total Firm Energy Production† (MWH)
			MAX.* (ft.)	MIN. (ft.)								
G	Power and Major Storage	25,440,000	2050	1925	125	14,100,000	21,550	338	8	1,920,000	1,392	4,620,000
E	Power and Minor Storage	26,000,000	1650	1550	100	5,150,000	34,350	318	12	2,628,000	1,896	6,908,000
A	Power and Minor Storage	48,400,000	1280	1255	25	1,060,000	37,590	350	12	2,929,000	1,932	8,152,000
									TOTALS	7,477,000	5,220	19,680,000

*Refers to normal maximum water level.

†Electric energy which is intended to have assured availability to the customer to meet all load requirements.

3. INTERGOVERNMENTAL CONSULTATION REQUIREMENTS

In view of the possible future water resource developments in the Mackenzie River Basin that have been outlined in this information exchange, it is suggested that efforts be made to assess what basic data would be required to provide the basis for judging the effects that these developments will have on other users. A comparison of the basic data required with that already being collected would show the gaps in the existing inventory system. A programme of priorities could be established for collecting the missing data.

The type of data required to establish an inventory of the water resources of the basin should include streamflows, lake levels, sediments, snow depths and precipitation, temperature, water quality and aquatic measurements. In addition, topographic data such as stream profiles and cross-sections, lake soundings, air photograph coverage and mapping should be considered.

There should also be discussions from time to time between those governments that are directly concerned in any upstream development that could affect the downstream planning. An example of this would be any proposal for development plans in the headwaters of the Liard River located in Yukon Territory.

Another factor is the possibility of accelerated economic growth in the Mackenzie Valley. Major changes in the transportation system with recent suggestions of a road through the Mackenzie Valley could have an effect on water transportation.

Accelerated economic growth may open up opportunities for power market in the north.

Northern Region Group

Water Resources of the Mackenzie River Basin North of 60°

PREPARED FOR THE NORTHERN REGION GROUP JOINTLY BY DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT, GOVERNMENT OF THE NORTHWEST TERRITORIES, AND GOVERNMENT OF THE YUKON TERRITORY.

Contents

Water Resources of the Mackenzie River Basin North of 60°

1. INTRODUCTION

The Department of Indian Affairs and Northern Development, with its provincial type role in water resources management north of the 60th parallel, and in close co-operation with the Territorial Governments of the Yukon and Northwest Territories, must, at this time, take a long view into the future when considering co-operative management of the water resources of the Mackenzie River Basin. The Northwest Territories is in the unique position of being the only downstream jurisdiction of North America's only major northward flowing river system. Its position is also unique because both the major water demands for, and the main areas of origin of the Mackenzie Basin waters are upstream, outside territorial jurisdiction. Within the Northwest Territories itself, demand for water for such major conventional uses as irrigation, or industrial or municipal intake, is but a fraction of the available supply, a situation that will not likely change significantly because northern agriculture and population growth is not expected to expand to levels comparable to the upstream provinces.

It is recognized that requirements may at some future date call for diversions or other works that would alter the regime of the Mackenzie or Liard Rivers to some degree in the N.W.T., and there must be assurance that northern interests are fully protected. The recent environmental difficulties encountered in the Peace/Athabasca Delta signalled the need for closer consultation and study, *on a basin basis,* of the impact of such works in their planning stages.

Knowledge of preliminary planning in Alberta and British Columbia to develop or divert the headwaters of the Mackenzie Basin has also raised concern, and, in our view, made it mandatory for consultation to take place among jurisdictions and for careful assessment to take place on the downstream (i.e. territorial) impact of such proposals. The concern of northerners in this regard was formally stated in a Motion of the Territorial Council of the N.W.T., which requested the Commissioner to pursue the initiation of a study "into the possible long-term effects on northern Canada if rivers draining into the Arctic should be diverted to the South".

It is evident that in the last few years there have been major steps taken in the field of inter-regional co-operation in management of the water resources of Western Canada, including the Apportionment Agreement, basin studies under the Canada Water Act, the Saskatchewan-Nelson Basin Study, and the Peace/Athabasca Delta Study. These activities have had, in the main, a west-east orientation, in the primary interest of the prairie provinces. Northward flowing waters have been implicated only in so far as they related to the basic west-east provincial concerns. With the establishment, in the last two years, of a water resources management capability in the Department of Indian Affairs and Northern Development with regional offices in Yellowknife and Whitehorse, and operating under new legislation, the time has now come when the North can work together with the provinces in the co-operative management of Mackenzie Basin waters, including research and data gathering work to fill the many current information gaps.

2. POLICY AND ROLE – DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

The Department of Indian Affairs and Northern Development is responsible for natural resources, other than game, in the two northern territories, and exercises a direct provincial type role in discharging this responsibility. In discharging this responsibility it works closely with the territorial governments, particularly through its regional offices in Yellowknife and Whitehorse.

In a recent statement of Federal Government policy for the North, the Honourable Jean Chrétien, Minister of Indian Affairs and Northern Development, presented the federal government's northern objectives, priorities and strategies for the 1970's. The main elements of the strategy are people, resources and environment, and the essence of the government's approach is to develop and encourage policies and programs that meet the needs of the native peoples, ensure viable economic development, maintain the ecological balance of the North and further the evolution of government in the Northwest Territories. It will be essential, in the years ahead, to ensure that an equilibrium is maintained among these three key elements, and the

northern position with respect to the water resources of the Mackenzie Basin will be conditioned by this basic requirement.

In his policy statement, Mr. Chrétien laid down the Government's order of priorities for the North for the next decade, several of which related clearly to management of the water resources of the Mackenzie Basin.

1. To give rapid effect to guidelines for social improvement of native peoples in the North. The guidelines, which are also part of the northern strategy for the 70's include maintenance of opportunities for native peoples to continue pursuit of their traditional hunting, trapping and fishing activities, and encouragement of a shift of emphasis to analogous activities (tourist guides, game wardens, etc.); both are equally dependent on maintenance of the natural environment.

2. To maintain and enhance the natural environment through such means as intensifying ecological research, establishing national parks, ensuring wildlife conservation.

3. To encourage and stimulate the development of renewable resources, light industries and tourism, particularly those which create job and economic opportunities for native northerners.

4. To encourage and assist strategic projects (key to increased economic activity in a region or territory with solid economic and social benefits) in the development of non-renewable resources and in which joint participation by government and private interests is generally desirable.

5. To provide necessary support for other non-renewable resources projects of recognized benefit to northern residents and Canadians generally.

The role of the Department of Indian Affairs and Northern Development in the Territories, in relation to other Federal departments was also clarified in Mr. Chrétien's policy announcement. There are some thirty federal departments and agencies active in the North at this time. The multiplicity of activities carried out raise inevitable problems of consultation and co-ordination, and the danger of confusion among northern peoples and industries operating in the North. The Minister of Indian Affairs and Northern Development has, therefore, been assigned the overall co-ordination role for federal policies and programs north of the 60th parallel. In the Northwest Territories, the Commissioner exercises this role through a co-ordinating committee. Acting with, and in many areas through the Territorial Governments, the Minister's authority is analogous to provincial jurisdiction in respect to both Territories and vis-à-vis other federal departments and agencies concerned.

3. WATER RESOURCES MANAGEMENT NORTH OF 60

One of the areas in which there has been a substantial recent increase in government activity in the North is that of water resources management. Some legislative tools have been on the law books for many years. However, increased pressure on water usage and a great public awareness of problems associated with water quality have given rise to the enactment of new legislation.

There are several items of legislation which have a direct bearing on the management of Mackenzie Basin waters in the northern territories.

The *Northern Inland Waters Act* is the legislative instrument for regional management of the water resources in each territory, and is similar to those already in effect in the four western provinces. It has four main purposes:

1. to provide for the equitable distribution or sharing of rights to the use of northern fresh waters, through a system of water rights licensing;

2. to ensure that the disposition of water rights is done in a manner consistent with immediate and long-term ecological and national interests;

3. to ensure that all works and undertakings planned for the use, diversion, storage and treatment of water are designed and constructed to acceptable engineering standards;

4. to establish and maintain the principle that a right to the use of water is dependent on the user accepting full responsibility for returning the water to the natural environment in a condition that meets acceptable water quality standards.

The Act was proclaimed on February 28, 1972, and will become fully operative later in the year when regulations are promulgated. In its operational application the legislation is administered by the Department's regional offices in each territory. Policy formulation, overall planning and co-ordination and special studies remain the responsibility of the headquarters offices in Ottawa.

The coordination of Federal and Territorial agencies in considering water licence applications is accomplished

through Territorial Water Boards, a forum unique in Canada, on which are represented the six main Federal Departments active in water resources in the territory, plus three members resident in the territory named by the Commissioner. The Boards are chaired by the Department of Indian Affairs and Northern Development.

Federal-Provincial-Territorial cooperation in the Mackenzie Basin, under the auspices of the *Canada Water Act,* will also have to take into account the requirements of the *Fisheries Act,* the *Migratory Birds Convention Act* and the *Canada Shipping Act.*

4. NORTHERN CONCERNS

There has been considerable expenditure of money, talent and energy in the last 10 years in the southern part of Canada on examination of schemes that would see diversion or development of the provincial headwaters of the Mackenzie River. Such work has ranged from tentative planning for a run-of-the-river hydro plant in the Peace River, which would not likely cause problems downstream, to grandiose schemes, on a continental basis, which could conceivably change the Western Arctic for all time. The evolution of such planning in the last decade has been motivated by requirements of an economic and social nature in southern populated areas. They have not, unfortunately, been accompanied by adequate efforts to understand the potential results of such schemes in the northern half of the Mackenzie Basin. The potential impact on navigation, fisheries, waterfowl, forests and other areas that result from the Mackenzie River being the lifeblood of the Western Arctic requires close investigation before significant headwater developments can rationally take place. While the past 10 years have seen intensive work on eventual southern use of Mackenzie Basin waters, the next 10 years should stress the northern implications, both on the natural environment the Mackenzie River sustains north of the 60th parallel, and on the people whose livelihood is dependent on the integrity of that environment.

Work that has been undertaken in recent years in studying the complex inter-relationships of water and other elements of the natural environment in the Mackenzie Basin north of the 60th parallel has provided some basic information that can be touched on in this paper. Much of the available information has been reviewed and reported on as part of the Saskatchewan-Nelson Basin Study.

4.1 Water Regime

The building of diversion dams and the diverting of stream flows would cause substantial morphological changes in the Athabasca-Mackenzie Basin. These changes could have profound effects on many activities that are carried on within the basin. For example, the lowering of lake levels can result in extensive dredging operations to maintain the navigational system. Aggradation, degradation and blocking of streams by dams could cause changes in fish migration patterns, together with damage to spawning areas, and so be harmful to the fishing industry.

4.2 Wildlife

(a) Waterfowl — The Mackenzie Delta is well known as a prime breeding area for ducks, geese and other waterfowl, including some endangered species. Also, the deltas, river mud bars and gravel flats are nest and feeding areas during the massive spring and fall migrations. In this context, Canada's international obligations under the Migratory Birds Convention Act dictate the need to maintain a natural environment that will sustain the waterfowl population.

(b) Big game animals — The River Valley floodplains provide food and shelter for large numbers of moose and caribou, especially during the winter months. These have been and continue to be a major source of meat for northern residents. More recently in time, moose and caribou have taken on new economic significance because of the potential of sport hunting by non-residents.

(c) Fur bearers — While the watershed supports several different types of fur bearing animals that are important in the trapping economy of the North, muskrat and beaver are the principal areas of concern here. Extensive muskrat trapping takes place in the Mackenzie and Slave Deltas, while the Mackenzie Delta is the main source of beaver. Mink is another important fur bearer found in the flood-plain lakes of the Delta. The concern here is to maintain the conditions which create and sustain these prime habitats.

It is estimated that the value of fur and big game animals taken by trappers and licensed sport hunters is in the order of $5 million, a figure which excludes the use of game for food, which approximates $3 million.

The existing biological cycle of the river and deltas of the Mackenzie Basin has developed in response to, and is maintained by, the unregulated river regimes. By far the most important characteristic of the system is the annual spring flood with its high flows and heavy siltations. The floods are of particular importance in the delta areas, of which two (the Slave and Mackenzie) are in the Northwest Territories. In the Mackenzie Delta, the rush of warm spring water causes the ice to break up in the upper reaches of the delta, forming ice jams which in turn force the flood waters

even higher to replenish and rejuvenate the parched lakes on the floodplains of the rivers and behind the levees in the delta. This rush of warm water also has the effect of creating a spring climate which is milder in the delta than in the surrounding area.

As water from the Peace and Athabasca systems is tempered by flowing through Great Slave Lake, the major contributor of the warm water is the Liard River. Any control or diversion on the Liard which delayed the spring peak on that river could seriously disrupt the climate and hence the ecology of the Mackenzie Delta.

4.3 Fisheries

The fisheries resource of the Mackenzie Basin is directly dependent on the interactions between rivers and lakes. The Slave River, for example, supplies nutrients to Great Slave Lake, and supports fish spawning migrations. Interference in the water regime that supplies Great Slave Lake could seriously jeopardize the major fishing industry. In 1969, 325 commercial fishermen caught approximately 6 million pounds of fish with a landed value of one million dollars. The catch was largely from the western part of the Great Slave Lake. The fish resources of the Mackenzie Delta also have considerable potential for harvesting. A further point which cannot be overlooked is the heavy reliance of native people on fish for domestic food supply.

4.4 Forestry

The forest resources in the territories' half of the Mackenzie Basin are centred in the Liard River and Slave River valleys. Initial estimates place the Northwest Territories' volume of merchantable timber at 2.0 billion cubic feet, and it is probable that resource will be harvested once transportation facilities are suitable and economic.

The Liard and Slave timber stands are located mainly on floodplains, and it is postulated that much of the resource is maintained by the spring flooding of the area with its attendant deposition of silt. Water resources planning in the upper portion of the Mackenzie Basin must take into account the ecological and economic implications to these reserves of timber.

The lower Mackenzie Valley too has some rather substantial stands of timber, particularly in the region from Fort Good Hope to Inuvik where preliminary estimates place the supply at approximately 3.3 million cubic feet. The significance of this timber lies in the fact that 90% of it is north of the Arctic Circle in a region which will probably experience considerable economic development during the 1970's.

4.5 Recreation and Tourism

Much of the future outdoor recreation and tourism development in the North will be water based in one way or another. Even those activities which are not usually associated with water, such as hunting, sight-seeing and hiking, make extensive use of water as a support or service commodity. Boats, canoes, and float-equipped aircraft are likely to become increasingly important as the primary means of access to any given sites.

Mackenzie Highway tourist traffic will demand river viewing opportunities coupled with boat launching facilities and river crossings.

The majority of the lodges and outfitters catering to hunters and fishermen in the Northwest Territories are located on the Mackenzie system. This multi-million dollar industry is entirely dependent on the natural environment and the intelligent use of it.

The designation of a new national park on the South Nahanni River provides the second such park in the Basin. At the same time, the National Park Service is actively surveying a number of tributaries on the west side of the Mackenzie which might be designated as wild river parks.

As part of the International Biological Program a number of wilderness areas are being examined for designation and protection. Together these features constitute what will be a major attraction for tourists and recreation seekers later in the decade. Coupled with the established hunting and fishing potential of the Basin, it is obvious that recreation and tourism must be a major consideration of water resources planning and management.

The population of the Mackenzie Basin in the northern territories is not large in comparison to the populated southern half of Alberta. From Fort Smith on the Alberta border to the Delta communities of Inuvik and Aklavik, there are eighteen small communities along the 1200-mile long navigation route. For the people along the river system, however, the River is one of the dominant influences in their daily lives. It is the supply line in summer during the barging season; in many places, but particularly in the Mackenzie Delta area, it provides a ready winter ice road for crossings and travel along the river; it affords a handy community water supply; it provides fish for food and recreation; it harbours in its deltas fur bearers for either steady or intermittent trapping; and it plays a major role in enhancing climatic conditions in summer right to the Beaufort Sea. The sense of identification with the river is strong.

Probably nowhere along the system is the sense of

identification with the river more prevalent than in the Mackenzie Delta itself. The Indian and Eskimo populations of the Delta communities were here long before the white man. Both groups total approximately 3500 persons. Although trapping as a sole occupation has declined in recent years, many families still rely to some degree on income from hunting or trapping muskrats. In 1969-70, approximately 70,000 muskrats were taken by the two Delta communities of Inuvik and Aklavik. There is little doubt that changes in water levels and flow patterns in the Delta would adversely affect muskrat habitat, with consequent loss of income to the native people.

In conclusion, it can be stated that the concerns of the northern territories with respect to provincial water developments on the headwaters of the Mackenzie Basin are associated primarily with the possible adverse impact on the natural environment of the valley and the native peoples and renewable resource industries that depend on maintenance of the well-being of that natural environment.

5. RESOURCES DEVELOPMENT AND FUTURE WATER NEEDS

The presence of renewable and non-renewable resources that are much in demand in a given area tend to generate new forms and levels of economic activity through a series of stages over time and space. In this particular context there are the renewable resources of the North such as fish, wildlife, historic and scenic resources as well as the non-renewable resources in the form of minerals, oil and gas. While the former are generally developed, utilized or consumed in situ, the latter must first be found, extracted, processed and transported elsewhere for consumption. Once the location and value of the resources has been established, there is the problem of how to move in the necessary men and equipment, establish new facilities and a community and then transport the resources to consumers south of 60. In each case there are likely to be direct and indirect impacts on water. Several aspects of these problems are treated below.

5.1 Gas, oil and minerals

The development of these non-renewable resources has been the major thrust of economic activity in the Mackenzie Basin over the past 30 years and this will be increasingly so during the remainder of this decade. Since the search for oil and gas focuses primarily on the Tuk Peninsula, the Beaufort Sea and the Mackenzie River Valley, it is obvious that there are tremendous implications for water resources of the area. These implications cover the full range of potential water uses and hazards.

While the known mineral resources in the Mackenzie Basin differ in location from those of oil and gas, their present and potential impacts on water resources are substantial. These include water use for processing, power needs and the problems of waste disposal.

5.2 Pipelines and Highways

Transportation is becoming increasingly a critical factor in any resource development project of the types referred to above because of their size and relative remoteness from established transportation networks. While highways have always been important in this regard as have pipelines more recently, it is a new situation to have extensive development of both side by side in a northern environment. The water resource implications are primarily twofold: construction and operation of these facilities require large amounts of power while their physical location can create serious problems in any given natural water system especially during the construction phase.

5.3 Navigation

A critical and essential element in any considerations of the North is transportation. The primary objective is that the transportation system be dependable. Granted, the service should be provided as economically as possible but dependability is placed above cost in order of importance. Non-delivery can lead to human hardship and financial disaster, since it may not be possible to effect delivery again for many months. The most prominent characteristic of northern transportation is that it is almost always a mix of the various existing modes. Water transportation has and is pioneering the opening up of the North and it will undoubtedly continue to be a most important method of freighting goods north of the 60th parallel.

The inland water routes play a major role in the movement of people and material in the Mackenzie Basin, the Western Arctic coast and the Arctic Archipelago. The Mackenzie system also reaches into a number of metal mining regions which include Lake Athabasca, Great Bear Lake and Yellowknife, where in spite of an all-weather road, water transportation still accounts for over 50% of the resupply tonnage.

In winter, the summer shipping lanes become highways for convoys of rubber-wheeled vehicles escorted by snow plows. Supplies and freight can be moved rapidly and efficiently with minimal damage to the environment.

There are three future considerations of particular concern to navigation, in addition to present problems such as naturally occurring low flows, negotiating rapids and channel deposition. These considerations are hydro

development (especially on the main stem of the Mackenzie, which is unlikely), water withdrawal from the Mackenzie system, and competition from highway development in the face of rising costs for water transport over a short season.

5.4 Power

In the Yukon and Northwest Territories, power from present development is used almost exclusively to satisfy the needs of local mines, their adjacent settlements and other communities and small centres.

At present there exists only local power transmission lines in both the territories. No power grids or interconnections between the territories or between any province are presently in existence.

Due to hydrologic conditions in the region, mainly low annual precipitation, short frost-free period and the existence of permafrost, there are areas with little or no runoff. However some sites in the Mackenzie Basin appear suitable for hydro power generation. Some promising sites are on the Great Bear River; the Slave River; the Lockhart River and the Frances River at Frances Lake, the Kakisa River and the Little Buffalo River.

The location and scale of future hydro power developments in the Basin will depend on the kind of demand and its timing. There are essentially four aspects to future power demands in the Basin.

1. Local demands for new communities and community growth can be met with small hydro works and diesel or other comparable units. Also these needs can be met with power generated for other purposes.

2. Any extensive pipeline construction will require new sources of power larger than anything that presently exists within the Basin. The options to meet this need appear to be hydro and/or gas turbine units.

3. While mineral developments are not predictable until location, size, and nature of mining and processing the ore bodies are determined, it is anticipated that mining will have substantial new power needs in future.

4. Power exports from north of 60 have not been studied in detail to date. The export potential depends upon the availability and per unit cost of large blocks of power. At the present time this would require, in addition to the capital costs of the hydro site development, substantial investments in transmission lines. If power sites are to be developed and transmission lines built to service any pipeline construction, then it presumably becomes feasible to discuss the possibility for power export. However, power generation and transmission for export only are not foreseen at the present time.

   Our approach to hydro development in the Basin north of 60 in the years ahead will be to select the most promising sites, set priorities among them, establish hydrometric needs, collect and analyze data to establish costs, benefits, and environmental impacts – including the implications of evaporation from impoundments.

This is the water situation as seen today in the Mackenzie River Basin north of the 60th parallel.

Saskatchewan

The Mackenzie River Basin in Saskatchewan

SASKATCHEWAN DEPARTMENT OF THE ENVIRONMENT.

Contents

Synopsis

This background paper was prepared for presentation at the Mackenzie River Basin Seminar involving the Governments of Canada, Yukon Territory, Northwest Territories, British Columbia, Alberta and Saskatchewan to be held in Inuvik, Northwest Territories on June 24-27, 1972.

The paper describes the physical features, the people, economic activity and potential developments in the Saskatchewan portion of the basin. Existing and proposed data collection networks in the Saskatchewan portion are presented, and the needs and concerns of Saskatchewan related to resource management in the basin are outlined.

Saskatchewan recognizes the need for formulating a broad development strategy for the north so that development is carried out in an orderly fashion within a policy framework. Baseline information is required so that development alternatives can be evaluated in terms of environmental impact and effects on other resource developments or possibilities.

Saskatchewan is concerned that steps are taken to evaluate downstream effects of development proposals in the Peace and Athabasca River basins. There is also concern for the social and economic betterment of the native people of the basin.

The Mackenzie River Basin in Saskatchewan

1. INTRODUCTION

A quick glance at a map of the Mackenzie River Basin might give the impression that Saskatchewan's interest is probably limited since this province has such a small piece of the basin. However, this small piece represents more than 1/5 of the total area of Saskatchewan and a major chunk of her vast and valuable northern resources. These resources include relatively untapped mineral, forest, wildlife and water resources which have significance not only to the native people of the area but to the province as a whole in terms of major economic and social value. While the value of these resources is well recognized, it has become very evident during the preparation of this paper that there is a paucity of basic information relating to this area of the province. There is also the realization that the situation is not unique to the Saskatchewan portion of the basin, but is typical of the Mackenzie Basin as a whole.

2. DESCRIPTION OF THE SASKATCHEWAN PORTION OF THE BASIN

2.1 Physical Features

Approximately 45,000 square miles or about six per cent of the Mackenzie River basin is in the Province of Saskatchewan. All of this area lies within the Canadian Shield physiographic region of the province. Local relief rarely exceeds 60 feet, but the impression of ruggedness is felt because of the rock outcroppings and the terrain variations. Bedrock exposures and wetlands are characteristic features of the Shield. Rock basins, old glacial drainage channels and any depression in the bedrock are likely to be occupied by lake, muskeg, bog or marsh.

The area south of Lake Athabasca is a sandy, drift plain in which eskers, drumlimoid features, glacial lake plains and melt-water channels are locally prominent. An extensive area of desert-like sand dunes follows along the southern shore of Lake Athabasca.

Most of the Saskatchewan portion of the basin is between 1,000 and 2,000 feet above sea level. The area in the lower portion of the Fond du Lac River and surrounding Lake Athabasca is less than 1,000 feet above sea level — the lake itself is about 700 feet above sea level and is the lowest area in the province.

Much of the region is occupied by lakes and muskeg with indeterminate and chaotic drainage. The predominate hydrologic feature of the basin in Saskatchewan is Lake Athabasca which straddles the Alberta-Saskatchewan border but is largely in Saskatchewan. In 38 years of record, water levels on Lake Athabasca have fluctuated over a 12-foot range from elevation 681 to elevation 693.

The Fond du Lac, MacFarlane and William Rivers are the major rivers emptying into the lake from the Saskatchewan portion of the basin. The flow in these rivers is relatively stable all year round, with high peaks being retarded and smoothed by the dampening effect of the numerous lakes in the system. For a 23-year period of recorded flow near the mouth of the Fond du Lac River the mean annual discharge was 10,500 cfs or about 0.5 cfs per square mile of gross drainage area. Maximum and minimum recorded flows were 30,000 and 4,000 cfs respectively.

Other noteworthy hydrologic features are Cree Lake and the Cree River which flows into Black Lake on the Fond du Lac River; Tazin Lake and Tazin River in the extreme northwest corner of the province; and, further south, the Clearwater River which flows westerly across the Alberta-Saskatchewan border to the Athabasca River.

The drainage boundary of the Mackenzie basin in Saskatchewan separates the land areas that drain to the Arctic Ocean and to Hudson Bay. In this respect, there is an unusual feature in the province — Wollaston Lake at the eastern extremity of the basin has two outlets. Roughly ten per cent of the outflow from the lake flows via the Fond du Lac River into Lake Athabasca; the remaining 90 per cent flows down the Cochrane River which is in the Churchill River system. The question thus arises — where should the drainage boundary be drawn and what portion of Wollaston Lake local drainage should be included in the Mackenzie basin? The drainage boundary on published maps is usually drawn through the lake, often including the Geikie River, the major tributary to Wollaston Lake, in the Mackenzie River basin. It is suggested that the drainage boundary should pass through the height of land between these adjacent basins, and hence should be drawn through Red

Willow Rapids on the Fond du Lac River. This would put Wollaston Lake and its local drainage in the Churchill River basin.

2.2 Climate

This part of Saskatchewan can broadly be divided into two climatic regions: an arctic transitional region northeast of Lake Athabasca and a sub-arctic region covering the rest of the area. All of the area experiences a dry sub-humid climate with long sub-arctic winters and short, cool summers. Normal mean daily temperatures at Uranium City range from $-15^{\circ}F$ in January to $+60^{\circ}F$ in July. Temperatures as low as $-53^{\circ}F$ and as high as $+90^{\circ}F$ have been recorded. Mean annual snowfall in the basin varies from 50 to 65 inches, with Uranium City recording 55 inches. Mean annual total precipitation is in the order of 15 inches.

2.3 Soil and Vegetation

Podzol and Fibrisol are the dominant soils in the area. Podzol is the typical forest soil with a thin light-grey to white A horizon and a bright brown B horizon. Fibrisol is an organic soil with a thick layer of peat over a poorly drained mineral soil or Gleysol. These soils have sandy, mixed sandy and loamy, and loamy textures. There is no arable farm land in this part of Saskatchewan.

The area south of Lake Athabasca is characterized by lakes, bogs, forest patches and rock outcrops. The forest is dominated by closed-crown stands of northern coniferous trees, mostly spruce and pine. North and east of Lake Athabasca lies the sub-arctic lichen-woodland, an open coniferous forest with a prominent ground cover of grey and yellow "reindeer moss". These forests have not been commercially exploited.

3. THE PEOPLE OF THE BASIN

The main center in the Saskatchewan portion of the basin is Uranium City located on the north shore of Lake Athabasca. The 1971 population of Uranium City and district was about 2,200. Other communities with significant populations are the Village of Fond du Lac with a population of 200, and the Hamlet of Stony Rapids with a population of 150. In addition to these communities there are four Indian reserves in the Fond du Lac – Stony Rapids area with a total population of about 1,100.

Traditionally, the Indian and Metis of the area were involved in a subsistence type of living, utilizing the natural resources of their environment. While fishing, hunting and trapping are still important social and economic activities in the life of the region, mining and tourism provide the primary sources of revenue in the basin. The Indians and Metis people of the basin are becoming increasingly dependent on the white man's society due to inadequacies in their traditional incomes, inability to take advantage of specialized job opportunities because of lack of skills and, perhaps, incompatible social structure, and the availability of social welfare.

4. ECONOMIC ACTIVITY IN THE BASIN

4.1 Commercial Fishing

Commercial fishing is carried out on numerous lakes in the Saskatchewan portion of the Mackenzie River basin; the largest operation is on Lake Athabasca. Whitefish, lake trout, pickerel and northern pike, in that order, have the highest commercial value. The catch is processed or packed on site and sent to the southern markets. Most employees in the commercial fishing industry are Indians and Metis, many of whom derive a major part of their income from fishing; most, however, must supplement their income from other sources. Besides commercial fishing, subsistence fishing continues to be a part of the life style of the native people.

It is expected that the commercial fish production will stabilize in the near future in this area of the province but it is anticipated that the industry will become increasingly significant with the growing demand for fresh-water fish.

4.2 Trapping

While the relative importance of fur production has declined considerably since the 18th century and the early days of the fur trade, it is still of considerable significance to the residents of northern Saskatchewan. Trappers can no longer fully support themselves by selling furs, but it is an integral part of the life style of the native people.

Beaver, mink, muskrat and lynx furs are the most numerous and valuable in the basin. As in the days of early fur trade, many trappers still sell their furs through the Hudson's Bay Company and other private traders, but furs are also sold through the provincial Fur Marketing Service.

It is expected that fur production could be moderately increased in this area of the province.

4.3 Mining

There are two existing uranium mines in the area and a third under construction. Uranium was first discovered in the Beaver lodge district north of Lake Athabasca in 1935. Serious exploration began in 1944 and during the next ten years, 16 ore bodies were brought into production. Today, only the Crown corporation, Eldorado, is operating. Output

has declined in recent years due to falling demand and low world prices. It is anticipated that this situation will improve by 1975.

An open pit uranium mine is currently being developed by Gulf Minerals at Rabbit Lake, just west of Wollaston Lake. It is expected to begin production in 1975.

A very promising high-grade uranium discovery has been made by Mokta Limited near Cluff Lake south of Lake Athabasca. Although the company is optimistic regarding the potential of the area, it is not committed to development.

In addition to uranium there are known mineral showings of copper, gold, iron, nickel, silver and lead-zinc in the Saskatchewan portion of the Mackenzie basin.

4.4 Tourism

The area is very attractive to tourists in search of superb fishing, canoeing and the scenic beauty of the northern Saskatchewan wilderness. There are about 25 tourist camps or outposts in the basin primarily catering to the sports fisherman.

The Fond du Lac River and its tributaries provide excellent fishing for the prized Arctic grayling. In addition northern pike, walleye and lake trout are the most sought after game fish.

The tourist industry makes a significant contribution to the employment of the native people who work primarily as guides and dock help. There has recently been increasing emphasis on involving native people in operating tourist outfitting camps. The industry also creates a considerable demand for air services — the primary means of transportation in the area.

The tourist industry in this area of the province is considered to have a bright future.

4.5 Hydro Power

There are two existing hydro power plants in the Saskatchewan portion of the basin. In the late 1930's, Consolidated Mining and Smelting Company Limited built a power plant on the Charlot River, north of Lake Athabasca. This development, known as the Wellington Lake plant, has a capacity of 4.8 MW and is licensed for the use of the Charlot River flow plus a diversion of not more than 1,000 cfs from Tazin Lake. The diverted water is conveyed via the Charlot River to Lake Athabasca. The diversion facilities include a fixed weir at the outlet of Tazin Lake and a diversion tunnel 1,100 feet long and 14 feet in diameter. Regulation of diverted water is effected by the use of stop logs at the tunnel entrance. The Wellington Lake power facilities involve a dam at the outlet of White Lake and a 1,600-foot pressure tunnel 15 feet in diameter. The plant operates under a head of 72 feet.

In 1961 the company built a second power plant, called the Waterloo plant, on the Charlot River below the Wellington plant. This involved an earthfill dam at the outlet of Waterloo Lake and a centrally located power house and penstock. The Waterloo plant has a capacity of 7.5 MW operating under a head of 63 feet.

These two power plants are now controlled by Eldorado Uranium Company for their mining operations at Uranium City.

Recently, preliminary investigations of a possible hydro power development at Elizabeth Falls on the Fond du Lac River have been undertaken as an example of the kind of development that may be required in northern Saskatchewan in the future, and a preliminary assessment has been made of the requirements for environmental impact studies that should be undertaken before a final decision is made.

4.6 Transportation

Air travel is the primary means of transportation in the Saskatchewan portion of the basin. In addition to the several private companies providing non-scheduled services in the area, Norcan Air offers regular service between Prince Albert, Lac la Ronge, Uranium City and Stony Rapids.

Wheeled-vehicle transportation is limited to a few miles of local roads in the Uranium City and Stony Rapids areas. Railway transportation is non-existent.

Northern Transportation Company, which began operations in 1938 as a subsidiary of Eldorado Mining and Manufacturing Company, provides water transportation services to settlements on Lake Athabasca from the rail terminal at Waterways, Alberta. The navigation season begins in early May and lasts for about 160 days. Water transportation is also used for short distances by hunters, fisherman, trappers and prospectors in this area of the province.

5. DIVERSION POSSIBILITIES

Major consumptive usage of water in Saskatchewan is most likely to develop in the southern part of the province. Looking ahead, the day may come when the province will want to use more than its share of water in the Saskatchewan River system as provided by the Apportion-

ment Agreement signed in 1969 by the governments of Canada, Alberta, Saskatchewan and Manitoba. The agreement provides the opportunity for Saskatchewan to make up the Manitoba share of the Saskatchewan River by diverting water from northern streams. Hydro power and other considerations may limit diversion from the Churchill River system for this purpose unless perhaps diverted Churchill River water could be replaced. Thus it may not be unreasonable to expect that at some time in the future southward diversion from the Mackenzie system of some water to the Churchill may be seriously considered.

Three diversion possibilities originating in the Saskatchewan portion of the Mackenzie River basin were investigated in a preliminary way in the Saskatchewan-Nelson Basin Study.

5.1 Fond du Lac Diversion

By the construction of 11 low dams and associated pumping facilities along the Fond du Lac River it would be possible to divert water from Lake Athabasca to Wollaston and thence down the Cochrane River to the Churchill River system where it could be diverted by gravity to the Saskatchewan River. The total capital cost of such a scheme would approach 160 million dollars and operating costs would be very high. Quantities of water in the order of 20,000 cfs for seven months each year could be diverted by this route. Considering the costs and the demand for water it is unlikely that a diversion of this magnitude would be developed in the foreseeable future. However, a gravity diversion of up to 1,600 cfs for seven months each year could be obtained at a considerably lower unit cost and perhaps this could be given further consideration within a reasonable period of time.

5.2 Cree Lake Diversion

Diversion from Cree Lake to the Churchill River was also investigated in the Saskatchewan-Nelson Basin Study. A gravity diversion of up to 1,200 cfs for seven months each year could be made at the relatively modest cost of about two million dollars. It is felt that this diversion could be given further consideration in the foreseeable future.

5.3 Clearwater River Diversion

The Clearwater River could be diverted by gravity at Wesekamio Lake to the Churchill River. A firm flow of up to 1,900 cfs for seven months each year could be diverted at a cost of about 21 million dollars. This possibility would seem to be much less attractive than the Cree Lake proposal.

6. BASIC DATA COLLECTION

6.1 Hydrometric Data

There are currently four hydrometric stations in the Saskatchewan portion of the Mackenzie basin; these are on Lake Athabasca, Cree Lake, Fond du Lac River and MacFarlane River. An additional eight hydrometric stations have been planned within the next four years. These will be located on the Fond du Lac River above Hatchet Lake, Cree River at the outlet from Wapata Lake, Waterfound River below Durrant Lake, Tazin Lake, Clearwater River below Lloyd Lake, Greese River near Fond du Lac, Pipestone River above Cree River and Porcupine River below Grove Lake.

The expansion of the hydrometric network is dependent on funds available *and provincial priorities*. Locations of new stations are determined on an ad hoc basis, taking into account the accessibility and the availability of good hydrometric sites as well as striving for a good distribution of stations over the northern half of the province.

6.2 Meteorological Data

There are currently three meteorologic stations operating on a regular basis in the Saskatchewan portion of the basin. These are located at Uranium City, Cree Lake and Stony Rapids. There are other stations operated on a seasonal basis primarily for navigational purposes.

A new station at Cluff Lake is in the planning stage.

6.3 Water Quality and Sediment Sampling

Water quality and sediment survey stations are non-existent in the Saskatchewan portion of the basin and at this time there are no plans for establishing stations in the basin.

6.4 Other Data

Other basic data relating to fish, minerals, wildlife, and human resources are available through studies carried out as a part of regular information gathering programs of provincial and federal government agencies.

It is recognized that to enable large-scale multi-purpose planning studies to be carried out and to provide reasonably accurate estimates of the environmental impact of development proposals, much additional data collection and research are required.

7. NEEDS AND CONCERNS

In recent years there has been growing pressure for

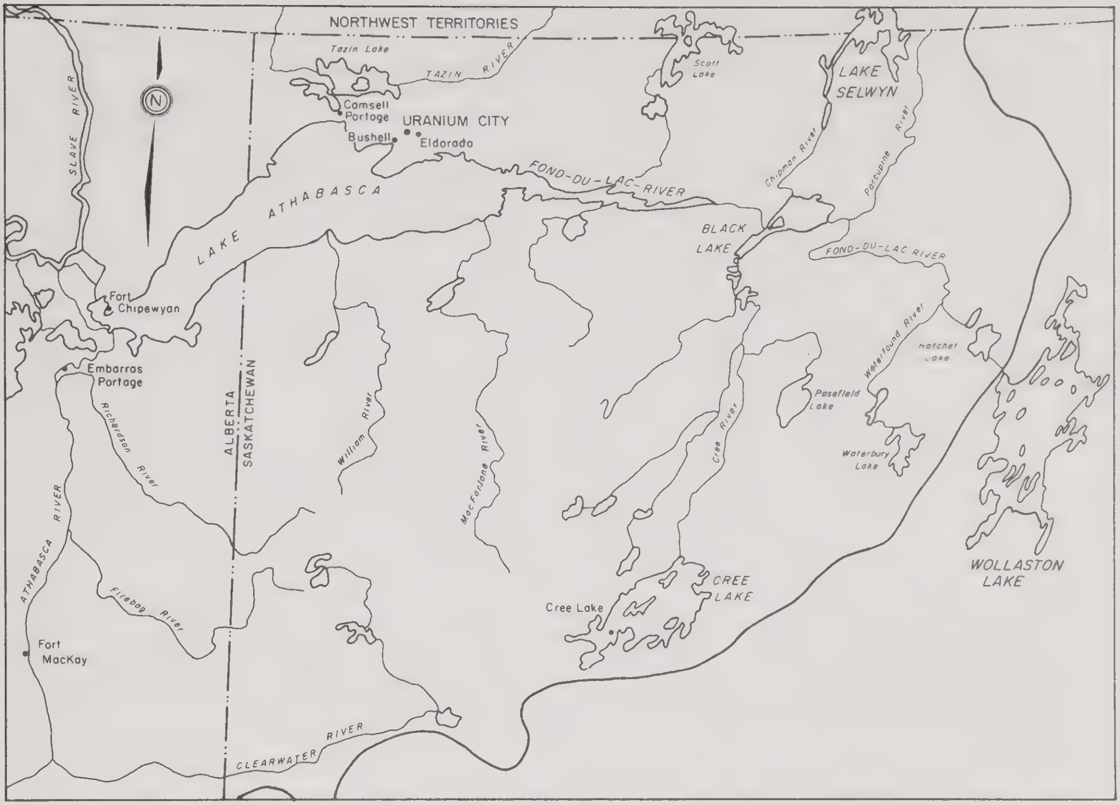


Figure 1. Mackenzie River Basin in Saskatchewan.

development in the north. At the same time there is an increasing concern for the preservation of the natural environment. To come to grips with these conflicting concerns, Saskatchewan recogizes the need for formulating a broad development strategy for the north so that development is carried out in an orderly fashion and within an articulated policy framework. To develop this strategy, studies related to inventory and potential of the resources of the area must be undertaken, including, and with special emphasis on, local people.

Baseline information is required so that development alternatives can be evaluated in terms of environmental impact, effects on other resource developments or possibilities for development, and effects on the economy and lives of the people in the area. Within the past year one major development proposal for northern Saskatchewan was cancelled due, at least in part, to a lack of basic information and the absence of a development policy. It is felt that as a first step in this direction, the time dependent data acquisition systems, such as the hydrometric and meteorologic monitoring networks, should be systematically expanded to provide an inventory of resources in the basin and to expand the available information on the interactions of these resources in the far north. Efforts should also be made toward initiating studies of various aspects of the economy and social structures of the area.

Saskatchewan is concerned that development proposals in the Peace and Athabasca River basins be analyzed in depth to evaluate downstream effects — in particular, the effects on water levels of Lake Athabasca. This province is also concerned that remedial measures designed to improve the water levels in the Peace-Athabasca Delta do not adversely affect the water levels and commercial fishing operations on Lake Athabasca.

There is major concern too for the native people of the north. It is felt that they must be involved in the planning stages of any development that may affect their social and economic well-being. Consideration should be given to

creating some structure which is representative of the people in the area to get views on what they feel should be studied. Efforts should be made to create job opportunities for the native people, and education programs should be initiated well in advance of development so that they may reap long-term benefits.

Discussions and Conclusions

Session II

Discussions on Need for Intergovernmental Action

Discussions

On completion of the presentation of background papers, the participants were divided into four working groups, each Group being representative of most of the jurisdictions holding a direct interest in the Basin. The task of each Group was to consider the three objectives of the Seminar which were: (a) to provide for an exchange of information and views on the water resources of the Mackenzie River Basin, (b) to assess the need for joint intergovernmental action, (c) to consider an appropriate course of action. Comments and alternatives were to be formulated by each group and reported to the plenary session at the end of the day.

Each Group appointed a leader and a rapporteur. The leaders chosen were Messrs. Blackwell, Marr, Bailey and Jones and the rapporteurs selected were Messrs. Howard, Bergasse, Mullins and Parkes. Dr. Prince acted as a roving delegate. A membership list for each group appears on page 6. The results of the group deliberations are summarized herein.

Group I

Group I agreed that there is a need for sound information on the Basin upon which future management decisions can be made. The starting point was thought to be an inventory of existing information such as hydrometric and biological data. However, it was noted that a data collection program would be expensive and time consuming.

It was recognized that there is a need to find a mechanism to ensure that the appropriate data base is being obtained, but it was not agreed how this could be achieved. In addition, a period of record is required in some instances if the information is to be valid. It was agreed that financial resources are limited and priorities have been placed on meeting the needs of the more developed areas of the south. Also it was felt that the Seminar has been an excellent means of focussing attention on the Basin and providing an appreciation of what is happening in the Basin. The large outstanding question observed by the Group was how to initiate the inventory of what is being done and what needs to be done. It was proposed that Environment Canada take the initiative. It was believed that the initial assessment would not be an expensive operation.

Group II

Group II also saw a need for an intergovernmental exchange of information on studies which are being carried out in each jurisdictional area of the Basin. The advantage of such an exchange would be to assist the respective governments to better identify the needs and priorities for additional studies within each region. This, in turn, would lead to a more positive collection and utilization of data.

Water quality and quantity data were recognized as being of prime importance. Data on groundwater, fisheries, wildlife, transportation and economic development, all as related to the water resource, should be added to the primary data. The time for expanding these types of investigations is now. The needs of the people in the area, their dependence on the water resources, and their relationship to the proposed utilization of the water resources must be of prime consideration.

The Group recognized that finding an acceptable course of action in the Basin is fraught with political difficulties. However, the desired result could be achieved by establishing an intergovernmental liaison committee at the senior official level to meet at least once a year to exchange information. It was hoped that such a committee would be established and meet at an early date. It was suggested that a meeting of ministers of the various jurisdictions take place at which time the terms of reference and composition of such a committee could be discussed. A formal water board was not considered necessary at this time.

Group III

Group III suggested the need for a total input of existing and future information into a central system. The initial data collected would be that which is available from the ongoing governmental programs and investigations. Data should be available in raw form, unclassified, and should be available to all parties and to the public. Financial limitations indicate the need for a limited data base, allowing a concentration of data collection efforts in key areas rather than superficial coverage over the entire area.

The Group also noted a need for an inventory of proposals, which, if implemented, could cause significant changes in the quantity, regime or quality of the rivers. In order to reach research or program objectives, such proposals must be identified. Any research program must relate to the needs of Canadians in general and northerners in particular. Primarily, there is a need to identify information gaps and take steps to obtain such information to place it in a readily accessible data depository.

This Group recommended that a systems approach be taken in order to avoid ad hoc decisions. Two alternative structures for the Basin were outlined: (a) a formalized Mackenzie Basin Institution or Agency and (b) annual or semi-annual coordination Seminars. The prime continuing function of either organizational structure would be the support of a data depository which could be located in a western Canadian University with strong northern involvement. It is proposed that the data depository would have a small secretariat which would meet semi-annually or quarterly at the working group level; public participation would be encouraged. It was stressed that initial financial support should come from the federal government, but within a short space of time, there should be financial participation by all involved parties.

Group IV

The Group noted that the information presented to the Seminar both by the formal papers and through informal discussions suggested that within the next ten years, pending major resource management developments such as hydro-power projects, diversions and storages would probably have significant effects elsewhere in the Basin.

Group IV recognized the interrelated nature of interests within the Basin. In planning large-scale developments the downstream effects will have to be taken into account by the agencies implementing the projects. Flows and water levels are considered to be critical factors. Major changes in the Mackenzie System flow could seriously affect navigation and possibly the ecology of the Mackenzie Delta. Thus in order that sound decisions be made, information must be gained to ensure future developments will be able to minimize any potentially harmful effects.

In light of this discussion, the Group suggested a number of action points. First, that a review of existing information on levels and flows be undertaken to gauge potential effects on navigation. In addition, a review of existing data concerning the relationships of the Delta ecology in relation to the Basin's jurisdiction, a cooperative assessment must be made regarding recommendations on the types of studies needed. Third, a range of formal and informal cooperative arrangements be considered to accomplish points one and two. This third point could be accomplished through a simple exchange of letters; working groups; task forces; or the formal establishment of a study board via an Order-in-Council.

In addition to these points, the view was expressed that public participation should be recognized and encouraged in the formulation and consideration of Basin objectives. Also, it was felt that a recommendation should be advanced to the plenary session that the proceedings of the Seminar should be made public.

Session III

Drafting Conclusions and Recommendations on Governmental Action

Lead delegates representing the governments met in the Third Session to consolidate the views and conclusions emanating from the four working groups. In doing so, particular attention was given to the Seminar objectives and the information presented during the earlier sessions.

Based on the results of working group sessions, it was clear that there are a number of areas of mutual concern, particularly in respect to data collection, information exchange and the lack of communication on planning and project development. One immediate result of the Seminar was that the delegates gained a better understanding of the objectives and activities of the other participating governments and their concerns and problems. This in itself is indicative of the need for continuing intergovernmental dialogue on the management of water resources of the Mackenzie System. Hopefully this would be the forerunner of a more formal intergovernmental arrangement to provide for improved co-ordination.

The conclusions of the lead delegates formulated at the Seminar and subsequently confirmed by an exchange of minutes are outlined below.

While many of the possible developments mentioned at the Seminar were conceptual in nature, the interdependence of the various regions within the Basin suggests the need for a better exchange of information among the several jurisdictions. Such an exchange would also encourage each jurisdiction to identify the needs and priorities for additional studies within its region.

Although the participants concluded that more basic data are needed, future action will depend on decisions by the leaders of the governments of the several jurisdictions. Because policies, budgets and priorities will be factors, five possible procedures were listed for their consideration:

(1) That an ad hoc group review and compile the information that now exists on such subjects as flows, water levels, river regimes, wildlife, fish, etc., and report their findings to each jurisdiction and agency concerned;

(2) That each jurisdiction undertake, on a continuing basis, to keep all other jurisdictions advised of its programs, data and information, by exchange of letters and reports;

(3) That a task force be established at the working level, with strict terms of reference and reporting responsibilities;

(4) That an intergovernmental liaison committee of senior officials be established. The committee should convene at an early date and meet at least once a year. Terms of reference of the committee would be established with the recommendation that they include provision for exchanges of information on developments in each jurisdictional portion of the Basin.

(5) That a formal board be established under joint cost-sharing agreements and under an intergovernmental agreement to conduct investigations, studies and related activities, and to report its findings and recommendations.

There was a general consensus that the most suitable of these alternatives would be the establishment of an intergovernmental liaison committee, as a vehicle for exchanges of information, investigations, and intended developments in each jurisdiction portion of the Basin. The background papers would be consolidated into a public information package.

Lead delegates then agreed to consult with their governments on the alternative courses of action proposed at the Seminar and to communicate these decisions to the Department of the Environment.